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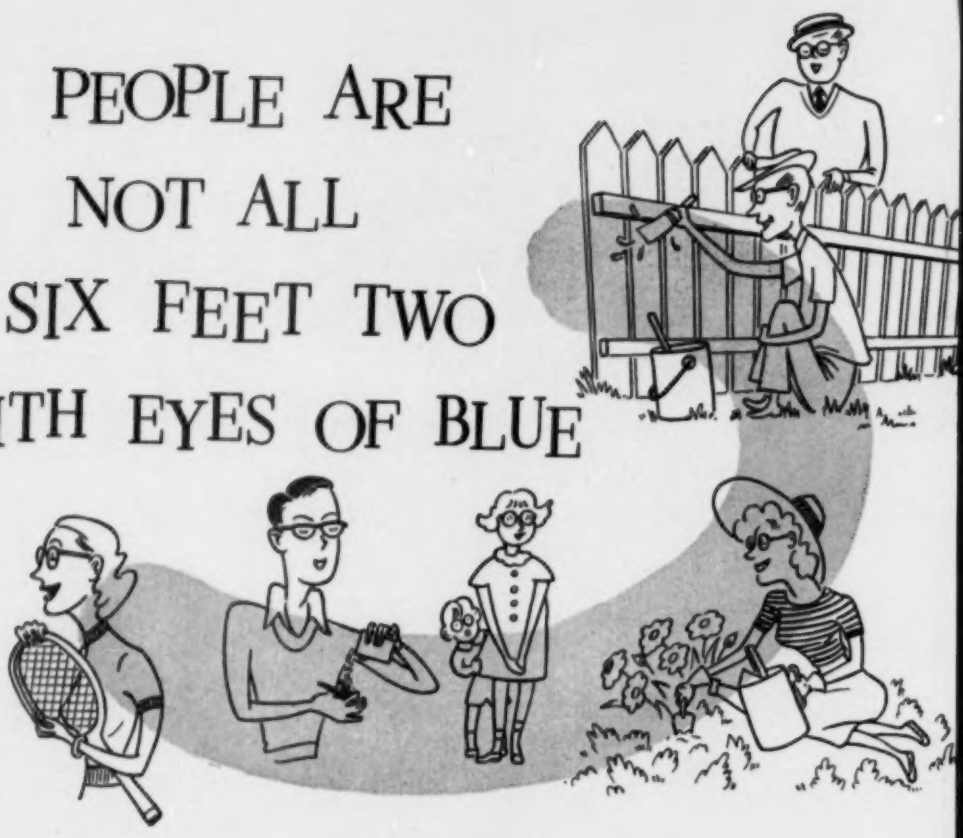

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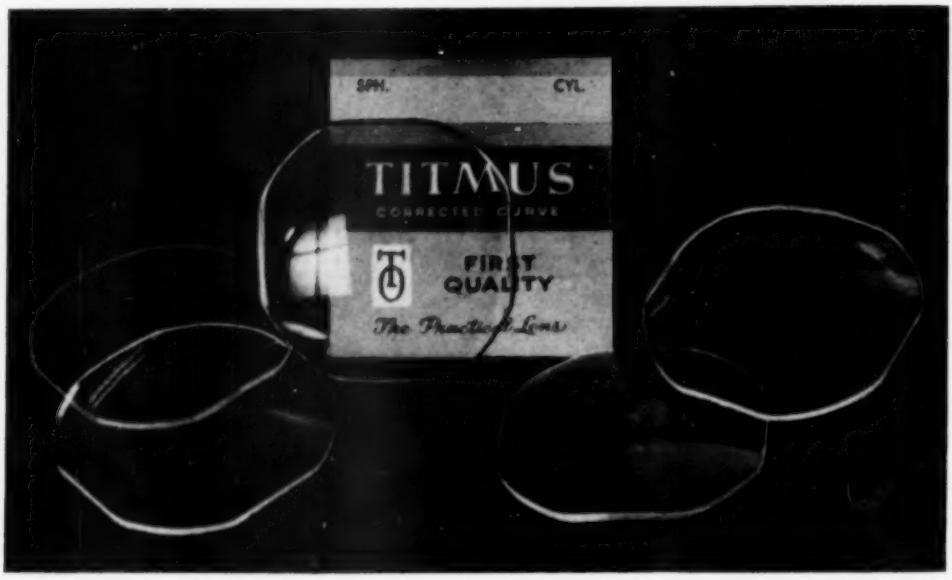

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INTEROCULAR TRANSFER OF AFTER-IMAGES?*

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In 1691, in a letter to John Locke, Sir Isaac Newton wrote: ". . . and, which is still stranger, though I looked upon the sun with my right eye only, and not with my left, yet my fancy began to make an impression upon my left eye as well as upon my right. For if I shut my right eye, or looked upon a book or the clouds with my left eye, I could see the [image] of the sun almost as plain as with my right eye, if I did but intend my fancy a little while upon it. . . ."

This was the original discovery that an impression on one retina can apparently be conveyed to the other. Newton's own observation did not become generally known until about 1830, but meanwhile others had made similar ones. The interocular transferability of after-images was being generally accepted by 1840, when Szokalski[1] made a claim beyond it: if a fingertip is used to put gentle pressure on one eyeball at the outer canthus, "a yellow fleck appears in the same corner of the other eye, if this eye is closed, and a blue fleck, if it is open." Here, the primary visual response, and not merely a secondary one, was being considered to be transferred to the unstimulated eye—worse yet, it was being considered to belong only to that eye. At this same time Jüngken[2] was promulgating a related error in his important textbook on ocular diseases. He stated that while monocular diplopia is ordinarily a product of nervous diseases, it can be elicited artificially by displacing an eye outward by tension on the skin at the outer canthus. One can indeed secure a complete doubling of visual objects in this way, but it is not a monocular diplopia.[3] Jüngken was apparently supposing that things which were being seen with one eye were actually being seen with the other.

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During the period when pressure phosphenes and diplopic images were supposed to be transferable from eye to eye, such suppositions probably furthered the acceptance of the transfer of simple after-images. Faith in this latter phenomenon is still firmly entrenched, as is indicated by the following statement by Duke-Elder[4]: "An induced after-image may be invoked by applying a primary stimulus to one eye, and then, when this eye is closed, directing the gaze of the other upon an illuminated surface."

Let us imagine some simple experiments in a darkroom, with projectors and a screen. The original, or inducing, stimulus is a photopic spot of light viewed for about half a minute with the right eye, the left eye being covered.

First, the stimulus is presented and then removed with the room left totally dark. The observer now enjoys an after-image. It stands in space wherever he "looks." Depending upon circumstances, it may go through positive and negative intensitive phases; it may take on colors in a certain order; it may be simply complementary to the original stimulus (if that was colored). In any case, the image cannot be introspected to belong to a given eye, but seems to be binocular. It is as steadily present as if it were binocular, for it does not rival with something else as a monocular stimulus will do when both eyes are viewing real stimuli.

Now, the inducing stimulation is repeated but this time the screen is subsequently flooded with an illumination which can be varied in intensity. If the left eye is kept closed, the observer sees an after-image of the spot wherever he fixates on the lighted screen. It may be made positive, or more strongly negative, by lowering or raising the illumination, etc. If the right eye is now closed and the left is opened, the after-spot is still seen on the screen. It is not so distinct, nor so continuous, nor so long-lasting; but it is there. The question is, *is* it being seen by the left eye?

Such an after-image can be seen in the dark. It can be seen with both eyes closed. It cannot be assigned, at such a time, to either particular eye. If it is seen "on" a lighted screen when only the left eye is open, is it not perhaps really being seen only by the (closed) *right* eye? It would then still be seen wherever the left eye is fixating, for the automatic accommodative convergence would be aiming the closed right eye at about that same place on the screen too. Thus the right eye's after-image, for the seeing of which the right eye need not be opened at all, is perhaps being "projected" into the field of the open left eye, just as the hole is projected within the outline of the hand in the familiar hole-in-the-hand illusion.

Has anything, then, been transferred from eye to eye at all? Clearly we can at least say, "not necessarily." There is no known anatomical opportunity for a retina-to-retina transfer in the first place. Even at the level of the lateral geniculate nuclei, where each of these ganglia receives the tract fibers from the ipsilateral temporal hemiretina and also those from the contralateral nasal hemiretina, there is no opportunity for binocular "fusion" nor for a transfer of any activity in the pathways from one retina into the pathways from the other retina.[5]

Only when messages from binocularly correspondent hemiretinas have arrived in the cortex of Area 17 does it become possible for information from the right eye to get into the circuits from the left eye, so as to come into consciousness as if it had been sent up from the left eye or from both eyes.

If, then, there is to be any transferring of after-images from a stimulated eye to a non-stimulated one, this will actually have to be an intracortical transfer. Within each hemisphere, such a transfer might be possible between the representations of the contralateral nasal hemiretina and the ipsilateral temporal hemiretina. It might be that a transfer could be effected in one direction—say, nasal-to-temporal—but not also (or not as efficiently) in the other. It might also be that a transfer could be made from the nasal (or temporal) hemiretinal representation in one hemisphere to the representation, in the other hemisphere, of the nasal (or temporal) hemiretina of the other eye.

For the testing of these possibilities, after-images such as have so far been mentioned here are unsuitable. They are of intensitive and/or chromatic character and have their bases within the retina in phenomena which are essentially or exclusively chemical, and characterized by slow decay. Perhaps when they are seemingly seen with an open and not-previously-stimulated eye, this is only because they are actually being seen with the other, previously stimulated, eye even if that eye is not being kept open. Or, the apparent transfer of such after-images may be genuine. The rationale of Brock's[6] test for anomalous correspondence assumes that it is. From anomalous corresponders of different kinds, evidence can be obtained which points in opposite directions,[7] so that the situation is ambiguous.

What is needed is an after-effect of such character that it is seen only in the presence of, or as affecting the appearance of, a new visual stimulus. If stimulus *A* is given to the right eye alone and establishes an after-effect which is invisible in the dark or with the eyes closed, and this after-effect changes the appearance of a new stimulus *B* for the right eye but does not change it for the left eye, then probably nothing has been

transferred anywhere. But if the after-effect of *A*, invisible to the right eye if that eye is closed, makes *B* look different to the left eye from what it would have looked if *A* had never been given to the right eye, then it would seem that something has been transferred somewhere in the system.

An after-effect which meets these requirements lies at hand in the form of the so-called negative motion after-image. This was first studied extensively by Addams,[8] who discovered it while watching the seventy-foot Falls of Foyers on the shore of Loch Ness. When he looked away from the falls at motionless objects, these appeared for a time to be rising up into the air. Addams found other situations, both natural and artificial, in which the same reversed apparent movement could be obtained as an after-effect. Apparatus for the production of the "waterfall illusion" is still offered by psychological supply houses.

In 1849, Plateau[9] discovered a new means of eliciting a motion after-image. He employed a disc upon which he had drawn a delicate archimedean spiral, in white on a black background. When this was centrally fixated during its rotation, the observer saw an endless progression of rings, which either expanded or contracted depending upon the direction of rotation. After a few seconds of this, if the disc was abruptly stopped, the turns of its spiral immediately appeared to shrink (or expand); or, if the observer looked at any other object of about equal subtense (such as the experimenter's face), this was seen as undergoing an astonishing and continuous enlargement or contraction as the case might be.[10]

The Plateau spiral (or the heavier and tighter involute spiral preferred by Ernst Mach) shares an important property with all commonplace photopic stimuli which induce motion after-images, such as waterfalls, rotating calibrated drums and dials, roadways watched from vehicles, etc. This is, that no after-effect is experienced with the eyes closed. A new stimulus must be offered, and the after-effect is manifested as an altered mode of perception of this stimulus, to which an apparent movement is imparted. If the inducing stimulus is simply halted, it itself can become an eliciting stimulus. Set then in slower motion in its original direction, its "positive" real movement can be used to balance out exactly the negative after-movement, so that the magnitude and duration of the latter can be quite objectively measured.

The extensive literature of the motion after-image—much of it relating to the spiral inducing stimulus—has been well reviewed by Boring[11] and particularly by Hofmann.[12] The clinical applicability of the phenomenon has recently been explored in Switzerland.[13]

It was apparently Dvorak,[14] a student of Mach's, who first noted that if a rotating spiral was viewed for a time with only one eye, then was stopped and viewed with only the other eye, the after-effect was seen ("... just as in other visual after-images"[15]). This apparent eye-to-eye transferability of the negative motion after-image has been confirmed by half a dozen investigators.[12]

When two contrarily rotating spirals are respectively imaged upon binocularly correspondent areas in the two retinas, their after-effects neutralize if both eyes are kept open; but if either eye is closed, an after-effect is seen—somewhat diminished—appropriate to the inducing stimulus which had previously been given to the eye which remains open.[12] This shows that a transferred effect is not strong enough to defeat a direct effect of opposite sign.[16] Apparently it is only for the sake of ascertaining this, that binocularly correspondent areas have been studied. No one seems to have looked to see whether or not a transfer can take place *only* between such areas.

The crucial experiment is diagrammed in Figure 1. The observer, with his left eye covered, fixates a mark placed at one side or the other of a rotating Mach spiral, so that this is entirely imaged on one hemiretina in the right eye (Stage I). After a few seconds the right eye is covered, and the left eye fixates alternately two marks at either side of the now arrested spiral (Stage II). A motion after-image is seen whenever the inducing and eliciting hemiretinas are correspondent, but no effect is obtained when they are both nasal, or both temporal, hemiretinas.

Clearly a transfer of something, somewhere, does take place in this situation. It cannot be argued that something which is really being seen with the closed eye is being subjectively directionalized within the field of the open eye. The closed eye is assuredly seeing nothing, for following photopic stimulation the closed eye does not see, during the life of the after-effect, any "light chaos"[4] (upon which the negative after-image of motion can apparently be projected[13]).

The inevitable interpretation is given in Figure 2. Information arriving in one cerebral hemisphere from one hemiretina can alter the state of the pathways which bring, to that same hemisphere, information from the homonymous hemiretina in the other eye. The transfer of effect is intra-cortical, perhaps right in Area 17, and is confined to one hemisphere. There can be no transfer of activity from the representation of one hemiretina in one occipital lobe to the cortical representation of either of the hemiretinas which project to the opposite occipital lobe.

This is in sharp contrast to the behavior of apparent movement of the phi type, which freely jumps between hemispheres. If two phi

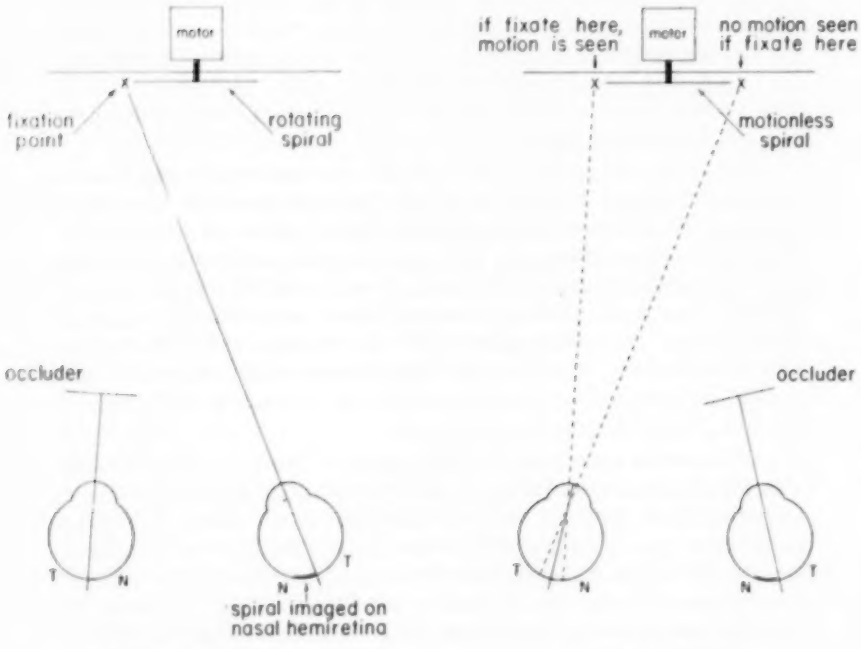

FIGURE 1

stimuli are imaged on opposite sides of the decussation line in one retina, or on the respective nasal or temporal hemiretinas of the two eyes, phi movement is as readily seen as when both stimuli are on one hemiretina. This may mean that different aspects of visual movement are registered in different cortical areas, between some of which there is inter-hemispheric communication and between others, none.

The intra-hemispheric "interocular" transference of the after-effect of visual movement can be added to the extremely brief list of phenomena which are indicative of any binocular sensory integration of a character which could be called physiological.[17] Its occurrence proves nothing one way or the other regarding the transferability of after-images which do not involve movement but are only intensitive or chromatic. This latter matter remains as ambiguous as ever.

It is easily shown that the negative motion after-image can transfer both from a nasal cortical hemiretina to the ipsilateral cortical temporal

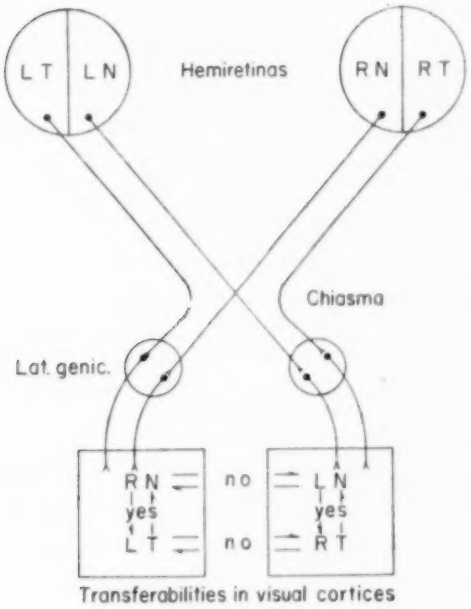

FIGURE 2

hemiretina, and from the temporal representation to the nasal representation in the cortex of the same hemisphere.

Indeed, if this were not true there would not be transfer of the spatial entirety of the effect when the inducing stimulus is centrally fixated. It has not been determined whether the after-effect is transferred more strongly in one of these directions than in the other; but, since it is possible to measure the amount of effect, this can and will be studied.

Visual-physiological differences between the nasal and temporal hemiretinas and their connections, some of them known for a long time, are beginning to receive revived attention.[18, 5] The differences must be involved in binocular vision—in which the two eyes make "unequal" contributions to the extent of such differences—and some of them may have *had* to be brought about, phylogenetically, in order for human binocular vision to be able to evolve at all. The binocular system is not simply a team of retinas. It is two teams of hemiretinas, and each of these teams is a horse-and-pony combination. Motion after-effects may prove valuable in the analysis of the manner in which the moieties of the binocular vision system *do* cooperate.

REFERENCES

[1]Szokalski, V. F.: Essai sur les sensations des couleurs, Bruxelles, 1840.

[2]Jüngken, J. C.: Die Lehre von den Augenkrankheiten, Dritte Auflage, Berlin, Albert Forstner, 1842.

[3]At most, an elongation of objects or a doubling of *outlines* may occur for one eye, when an astigmatic cornea is mechanically deformed.

[4]Duke-Elder, W. S.: Text-book of Ophthalmology. Vol. 1, St. Louis, C. V. Mosby Company, 1946.

[5]Walls, G. L.: The Problem of Visual Direction. Part II. The Tangible Basis for Nativism. Amer. J. Optom., 28: 115-146, 1951. Walls, G. L.: The lateral Geniculate Nucleus and Visual Histophysiology, Univ. Calif. Publ. Physiol., 1953.

[6]Brock, F. W.: Visual Training, Optom. Wkly., 41: 1699-1702 and 1715-1719, 1950.

[7]Walton, H. N.: A Study of Retinal Correspondence by After-image Methods, Amer. J. Optom., 29: 90-103, 1952.

[8]Addams, R.: An Account of a Peculiar Optical Phaenomenon Seen After Having Looked at a Moving Body, &c., Phil. Mag., Series 3, 5: 373-374, 1834.

[9]Plateau, J.: Quatrieme note sur de nouvelles applications curieuses de la persistance des impressions de la retine, Bull. Acad. Roy. Sci. Lett. B. A. Belg., 16:(2) 254-260, 1849.

[10]This version of the effect was important not only because of the simplicity of the apparatus, but because it blocked a false trail of explanation—Helmholtz's eye-movement theory of the effect. The eye could not move in all meridians at once, to account for the centrifugal or centripetal movement in the after-image.

[11]Boring, E. G.: Sensation and Perception in the History of Experimental Psychology, New York, D. Appleton-Century Company, 1942.

[12]Hofman, F. B.: Physiologische Optik (Raumsinn), In: Handb. d. ges. Augenheilk. (ed. Graefe, Saemisch), 2. Aufl., Bd. III, Kap. XIII, Leipzig, Engelmann, 1925.

[13]Bodenheimer, R.: Studien am Bewegungsbild und Bewegungsnachbild. Basel, S. Karger, 1952.

[14]Dvorak, V.: Versuche uber die Nachbilder von Reizänderungen. Sitzungsber. k. Akad. Wiss., Wien, math.-naturw. Kl., 61: 257-262, 1870.

[15]Wohlgemuth, A.: On the After-effect of Seen Movement, Brit. J. Psychol., Monog. Suppl. 1, Pp. 117, 1911.

[16]It also emphasizes that it is the motionless eliciting stimulus that actually sets off the after-effect. A non-seeing eye may influence the effect being seen by way of the other eye, but cannot institute an effect of its own since it is being given no stimulus to work upon.

[17]Walls, G. L.: Is Vision Ever Binocular? Opt. J. and Rev. Optom., 85:(15) 33-43, 1948. Walls, G. L.: Binocular White From Red and Green, and the Three-component Theory. Brit. J. Ophth., 36: 67-74, 1952.

[18]Broendstrup, P.: The Functional and Anatomical Differences Between the Nasal and Temporal Parts of the Retina, Acta Ophth., 26: 351-361, 1948.

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A CLINICAL STUDY OF CONVERGENCE INSUFFICIENCY*

PRELIMINARY REPORT

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PREFACE

One of the earliest and still widely used systems of case analysis classifies visual problems, on the basis of appropriate syndromes, into one of the following four types: (1) Accommodative insufficiency. (2) Accommodative excess. (3) Convergence insufficiency. (4) Convergence excess.

It remains for clinical research to determine whether such a system, or any other system of case analysis, has the desired validity and reliability. That is to say, does the system consistently give the same results, allowing for physiological changes and changes brought about by rehabilitation procedures and, is it valid in the sense that it measures that which we want to measure?

Regarding reliability, it is obvious that any system can be only as reliable as the individual tests on which it is based. The problem resolves itself therefore into a search for more adequate tests with higher reliabilities. The problem of validity is settled in terms of criteria arbitrarily selected. We wish to measure those things which will tell us if a given patient has, will have or can be given: (1) Standard visual acuity. (2) Visual comfort. (3) Visual efficiency.

Standard visual acuity should really be included under point (3), but it has been treated independently so universally that we will continue this convention. It must be understood, however, that all three are interrelated and that any fully adequate diagnostic system must take account of this fact. If our system of case analysis is selected according to the above criteria and it is practicable and universally applicable, there remains the dual problem of diagnosis and treatment. If I classify a given case as type X, I must be able to justify my position that the tests used in the classification truly differentiate this type, as a clinical entity, from any other type. The diagnosis once made should, furthermore, immediately suggest a line of effective and rational treatment.

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INTRODUCTION

Let us assume that the classifications of the system of case analysis under consideration are true clinical entities and examine the tests on which the diagnosis is based. Consider the third type, "convergence insufficiency," which is believed to be a rather common condition and is generally defined as a dysfunction in the ability to converge.

Duke-Elder[1] considers it to be present when the near point of convergence is approximately 3.8 inches from the apex of the cornea, orthophoria at distance, a periodic increase of divergence at the near point, low prism convergence (below 8°) and normal prism divergence.

Berens and Zuckerman[2] consider it to be present when the exophoria for distance is equal to 2 prism diopters, exophoria at near point 20 prism diopters, and the near point of convergence equals 8 inches. Borish,[3] in reviewing the work of various investigators, describes convergence deficiency in terms of a syndrome of tests which vary statistically in the same direction when compared to a norm, but which seem to have no other clear inter-relationship. The convergence near point is not considered in the syndrome. Cushman and Burri[4] consider convergence insufficiency to be present when there is an outward deviation, under cover, at the near point larger than it is for distance. They also point out the necessity of considering the patient's complaint in making an adequate diagnosis.

Mann[5] considers the most characteristic finding in convergence insufficiency to be the inability of the patient to perform voluntary convergence easily. Martin[6] states that in convergence insufficiency there is usually a remote near point of accommodation as well as convergence. Halper[7] considers at least some cases of exophoria to be the result of convergence insufficiency due to "weakness" of the bilateral adductor action. Maude[8] speaks of convergence fatigue which is related to subjective symptoms when working at the near point. Prangen[9] states that an anomaly of lateral balance is primarily one of either convergence or divergence.

It is easily seen from the above that there exists a variety of factors and tests which investigators believe to be related to convergence insufficiency and the need for a standarized diagnostic syndrome and the elimination of extraneous data becomes evident.

The most generally accepted variables affected by, and therefore indicative of the presence of the condition, seem to be: (1) A remote near point of convergence. (2) An increased exophoria at far or near, or both. (3) A lowering of the test findings which measure adductor action.

Regardless of the etiologic factor responsible, whether it be divergence excess or accommodative deficiency or a true dysfunction of convergence, they would tend to reflect themselves by changes in the above mentioned three variables. This would simply mean a difference in treatment rather than in diagnosis. The findings selected for this study are in accord with this conclusion.

PROCEDURE

The findings selected for this study were: (1) Near point of convergence (to objective diplopia). (2) Habitual phoria at distance. (3) Habitual phoria at 16 inches. (4) Base-out to break at distance. (5) Base-out to break at 16 inches.

All tests were performed according to standard procedure. The habitual rather than the induced phorias were selected in order to evaluate the effect of uncorrected ametropia and, consequently, indirectly of the accommodation. A total of 120 cases were studied, selected from the Public Eye Clinic of the Chicago College of Optometry. The cases were divided into two groups—group A, the deficient group (78 cases), and group B, the control group (42 cases). The objective was to study: (1) Differences between defective and control groups. (2) Relationship of diagnostic tests within each group. (3) Comparison of effectiveness of different diagnostic symptoms. (4) Evaluation of the condition as a clinical entity.

The problem which immediately arose was on what basis the defective group was to be selected. Since there were no established procedures, the cases were selected on the basis of three criteria as follows:

Group A-I: (55 cases) Near point of convergence more remote than 4 inches.

Group A-II: (10 cases) N.P.C. more remote than 8 inches.

Group A-III: (23 cases) Near habitual phoria greater than 10 prism diopters of exophoria.

The 10 cases of Group A-II were selected out of the A-I group. This provided a secondary control as well as an indication of the reliability of the testing procedure.

The control group (Group B—42 cases) consisted of randomly selected cases from the same population who had no visual discomfort and who were diagnosed as having no specific visual problem.

The convergence near point is said to vary with age, increasing about 5 mm. or so every 10 years up to the age of 40,[2] although such an effect is denied by Emsley.[10] A trend in this direction was indicated in our preliminary work and so, in order to eliminate this factor as far as

possible, the age group of the subjects was limited to a range extending from 7 to 29 years, the mean age being 26 years.

RESULTS

TABLE I

Norms and Reliabilities of Tests Used
A: Reliability—Shepard[11]
B: Expecteds—Shepard[12]
C: Expecteds—O. E. P.[13]
D: Expecteds—Haines[14]

Test	A	B	C	D
N. P. C.	.47	3.5″	—	—
Distance Phoria	.64	1x0	½ x0	ortho.
Near Phoria	.56	5x0	6x0	4.85x0
Distance Convergence	.62	21Δ	19Δ	22.26Δ
Near Convergence	.85	25Δ	21Δ	22.86Δ

TABLE II

Means, Standard Deviations and Standard Errors of Means of the Distributions Studied.

Test		Group A-I	Group A-II	Group A-III	Group B
N. P. C.	M	6.3″	9.9″	4.4″	3.1″
	σ	2.00	1.59	2.20	2.00
	σM	.27	.53	.47	.31
Distance Phoria	M	1.6 exo	3.5 exo	2.5 exo	2.2 exo
	σ	3.60	3.07	1.35	2.80
	σM	.49	1.02	.29	.43
Near Phoria	M	6.5 exo	8.0 exo	13.6 exo	4.8 exo
	σ	3.80	3.55	1.80	5.47
	σM	.52	1.16	.39	.84
Distance Convergence	M	17.6Δ	15.4Δ	21.8Δ	21.7Δ
	σ	7.52	3.70	9.12	9.53
	σM	1.00	1.23	1.90	1.50
Near Convergence	M	18.8Δ	15.0Δ	21.9Δ	23.4Δ
	σ	5.95	3.30	8.10	6.80
	σM	.80	1.10	1.70	1.00

TABLE III

Fiducial Limits[15]
Population Parameter at 5% and 1% of Levels of Significance

Test	% Signifi.	A-I	A-II	A-III	B
N.P.C.	5%	± .54	±3.75	± .97	± .62
	1%	± .72	±5.40	±1.32	± .83
Distance Phoria	5%	± .98	±2.30	± .60	± .86
	1%	±1.31	±3.32	± .82	±1.16
Near Phoria	5%	±1.04	±2.62	± .80	±1.70
	1%	±1.39	±3.77	±1.10	±2.26
Distance Convergence	5%	±2.00	±2.78	±3.93	±3.03
	1%	±2.67	±4.00	±5.36	±4.05
Near Convergence	5%	±1.60	±2.49	±3.52	±2.02
	1%	±2.14	±3.68	±4.80	±2.70

TABLE IV

Differences, Standard Errors of Differences, Critical Ratios and Probability of of Positive Differences for "Unforced" Differences

Test	Group Diff.	Diff.	σD	C.R.	%	"C" 1%	"C" 5%
N. P. C.	AIII-B	+1.3	.57	2.2	.9861	2.8	2.1
Distance Phoria	AI-AII	+1.9	1.10	1.7	.9554	3.2	2.2
Distance Phoria	AI-AIII	+ .9	.57	1.5	.9332	2.8	2.1
Distance Phoria	AI-B	— .57	.65				
Distance Phoria	AII-AIII	+1.0	1.00	1.0	.8413	3.2	2.2
Distance Phoria	AIII-B	+ .33	.50	0.67			
Distance Phoria	AII-B	+1.33	1.10	1.2	.8849	2.8	2.1
Near Phoria	AI-AII	+1.46	1.30	1.1	.8643	3.2	2.2
Near Phoria	AI-B	+1.74	1.00	1.7	.9554	2.7	2.0
Near Phoria	AII-B	+3.2	1.40	2.3	.9893	3.2	2.2
Distance Convergence	AI-AII	+2.25	1.60	1.4	.9192	3.2	2.2
Distance Convergence	AI-AIII	+4.15	2.20	1.9	.9713	2.8	2.1
Distance Convergence	AI-B	+4.05	1.80	2.2	.9861	2.7	2.0
Distance Convergence	AIII-AII	+6.4	2.30	2.8	.9974	3.2	2.2
Distance Convergence	AIII-B	—0.1	2.40	0.04			
Distance Convergence	AII-B	+6.3	1.90	3.3	.9995	3.2	2.2
Near Convergence	AI-AII	+3.8	1.30	2.9	.9981	3.2	2.2
Near Convergence	AI-AIII	+3.1	1.90	1.6	.9452	2.8	2.1
Near Convergence	AI-B	+4.6	1.30	3.4	.9997	2.7	2.0
Near Convergence	AII-AIII	+6.9	2.00	3.4	.9997	3.2	2.2
Near Convergence	AIII-B	+1.5	2.00	0.75			
Near Convergence	AII-B	+8.4	1.50	5.6	.9999	3.2	2.2

TABLE V

Correlation Matrix[16]

	Group A-I	Group A-III	Group B
N. P. C.—Distance Phoria	+.05	—.40	—.35
N. P. C.—Near Phoria	+.12	—.17	—.15
N. P. C.—Distance Convergence	—.47	—.40	—.55
N. P. C.—Near Convergence	—.35	—.75	—.40
Distance Phoria—Near Phoria	+.65	+.60	+.55
Distance Convergence—Near Convergence	+.80	+.25	+.65

TABLE VI

Values above which "r" is significant

	A-I	A-III	B
5%	.30	.45	.35
1%	.35	.55	.40

DISCUSSION OF RESULTS

The reliability of the tests used as given in Table I places definite restriction on the data, but since these tests are no better or worse than those used by the great majority of practitioners, they may be accepted as comparable.

The obtained control means, as given in Table II, compare favorably to means obtained for such groups by other investigators, as shown

in Table I. This would indicate that the procedure used in the administering of the tests was reasonably reliable.

The fiducial limits given in Table III give the relationship of the sample mean, as found, to the population mean. The 1% and 5% levels of significance simply indicate that our prediction that the population mean lies within the limits indicated would be wrong 1 or 5 times out of a hundred.

The critical ratio is another test of significance between observed differences. It enables one to determine, in terms of sigma, how far below the average difference a difference of zero falls. A critical ratio of 2.7 is generally regarded as significant and a ratio of 3.0 as very significant. The critical ratio in this study was corrected for the limited number of cases by applying Fisher's "t" test with the appropriate degrees of freedom.[17]

Those findings which were "forced" differences due to the selection of the cases were not included in Table IV.

The A-I Group differs significantly from the control group B with respect to the adductor findings at far and near, the near finding differing by a very significant amount. This would indicate that those cases which have a remote N.P.C. will also tend to have a low adductor action as measured by these tests. The correlations (tetrachoric) between these findings and the N.P.C. are not as high, however, as might be desired for minimal predictability. Furthermore, with respect to the near adductor finding, the A-1 Group differs significantly from the A-II Group, although both groups supposedly include cases of convergence insufficiency.

The A-II Group differs significantly from the control Group B with respect to the adductor findings also. The difference in both cases, far and near, is very significant. Furthermore, this group differs from the control group by a significant amount with respect to the exophoria at near and, as will be seen from Table IV, is the only group where this phoria finding is significant. It would seem, therefore, that if cases are selected on the basis of an N.P.C. more remote than 8 inches, these cases will also exhibit low adductor findings as well as significantly higher exophoria at the near point. The fact that the far phoria is not significantly higher towards the exophoric direction in any of the groups would support the view of the majority of investigators cited above, namely that the far phoria is not involved in convergence insufficiency. It is to be remembered, however, that the conclusions reached regarding the A-II Group are only of a preliminary nature since the entire group consists of only 10 cases.

Group A-III differs from the control group in only one significant respect, namely the N.P.C. It will be noticed, however, that the correlation between the near phoria and the N.P.C. for this group is much below desirable predictability. With respect to all other findings, the A-III Group does not differ significantly from the control Group B. Thus there seems no reason to believe that cases of high exophoria, whether at near or far point, are ipso facto cases of convergence insufficiency. It will be noted that the accommodative convergence in this group is less than in any other group. The full significance of this has not been worked out in the present study.

CONCLUSIONS

Within the limits of this preliminary study one may reach the following conclusions:

1. There is at present no standard technique of diagnosing convergence insufficiency if, indeed, such a condition exists as a clinical entity.

2. The best indication of convergence malfunction seems to be the near point of convergence with the adductor findings as auxiliary indicators.

3. There is no relationship between the N.P.C. and manifest habitual phoria at far: and the relationship with the near phoria, although present, is not generally significant.

4. Three methods of diagnosis tested, based on N.P.C., phorias and adductor findings, are not comparable and do not give similar results.

5. There exists a correlation of approximately equal extent for all groups between N.P.C. and the adductor findings, but this is not high enough to enable us to select all cases of remote N.P.C. (and therefore of convergence insufficiency) on the basis of low adductor findings at near or far.

6. From personal observations of the cases studied it would seem that the presence or absence of convergence insufficiency as such is not indicative of the degree of acuity present or even of general visual efficiency according to required minimal standards of education and industry. There is, furthermore, serious doubt that it is significantly related to qualitative and/or quantitative presence or absence of visual comfort.

7. There are no specific subjective signs or symptoms which could be utilized in the diagnosis of the condition.

8. Test findings supposedly typically present in convergence in-

sufficiency were found only in a limited number of cases, where the N.P.C. was more remote than 8 inches.

9. There is no doubt that a condition of lowered convergence ability in a given patient may exist, but it is not as common as has been supposed: and what effect, if any, this condition has on other visual tests needs radical reappraisal. It would seem more likely that this is a symptom of a more general visual condition whose nature and effect on known visual functions need further study before it, too, is called a "case type."

While no sweeping generalizations should be made from this limited data, certain trends seem significant. A similar expanded study of this and other classifications of the system of case analysis in question would be most desirable before making definite conclusions as to the merits of the system as a whole.

It seems to us essential that the profession re-examine its diagnostic techniques in terms of the criteria cited above so that we may standardize not only our diagnostic procedures and tests, but our treatment methods as well.

REFERENCES

[1]Duke-Elder, Sir W. M. Stewart. Practice of Refraction. St. Louis. C. V. Mosby Co., 1949.
[2]Berens, C., and Zuckerman, J., Diagnostic Examination of the Eye. Philadelphia. J. B. Lippincott Co., 1946.
[3]Borish, I. M., Clinical Refraction. Chicago. Professional Press, 1949.
[4]Cushman, B., and Burri, C., "Convergence Insufficiency," American Journal of Ophthalmology, 1941, 24:1044-1052.
[5]Mann, I., "Convergence Deficiency." British Journal of Ophthalmology, 1940, 24:373-390.
[6]Martin, H. G., "The Practical Measurement of Accommodation and Convergence," American Journal of Ophthalmology, 1939, 22:406-412.
[7]Halper, P. A., "Evaluation of Accommodation and Convergence in Refraction," Illinois Medical Journal, 1940, 78:534-540.
[8]Maude, J., "Orthoptics and the General Examination of the Eye," Trans. Ophthal. Soc. Austr., 1941, 1:160-162.
[9]Prangen, A. de H., "Differential Diagnosis of the Phorias." Trans. Amer. Academy Ophthal. & Otolaryng., 1940, 45:60-65.
[10]Emsley, H. H., Visual Optics. London. Hatton Press, 1944.
[11]Shepard, C. F., Optometric Science in Practice. Chicago. W. R. Wolfe, 1942.
[12]Shepard, C. F., "The Most Probable Expecteds." Optometric Weekly, 1941, 32:538.
[13]"Introduction to Near Point Optometry." Optometric Extension Program. Duncan, Oklahoma, 1945 to date.
[14]Haines, H. F., "Normal Values of Visual Functions and Their Applications in Case Analysis." American Journal of Optometry, 1941, 18:1-8.
[15]Edwards, A. L., Statistical Analysis. New York. Rinehart & Co., 1946.
[16]Chesire, L., Saffir, M., and Thurstone, L., Computing Diagrams for the Tetrachoric Correlation Coefficient. Chicago. University of Chicago Press, 1933.
[17]Goulden, C. H., Methods of Statistical Analysis. New York. Wiley & Co., 1939.

THE RELATION BETWEEN PERCEIVED SIZE AND PERCEIVED DISTANCE*

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In a previous paper,[1] a theory was formulated in regard to the relationship between size and perceived distance. In essence the theory is as follows:

(1) The position of a point P in physical space, Figure 1, can be specified with reference to a system of rectangular coordinates. The

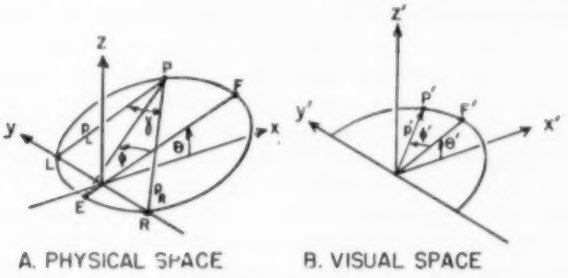

Fig. 1. The relationship of visual to physical space.

y axis coincides with the base line connecting the centers of the two entrance pupils (R. and L.). The x axis is the perpendicular bisector of the base line and may be inclined at any angle with respect to the head. The z axis is perpendicular to the other two. The x, y plane is the plane of Regard.

The circle passing through the point P and the centers of the two entrance pupils is the Vieth-Müller circle. It intersects the x, z plane at F. The position of the point P with respect to the entrance pupil of either eye may be specified by stating (1) its distance ρ from the center of the entrance pupil, (2) its angular displacement ϕ from the point F, and the dihedral angle θ between the x, y plane and the plane containing P and the y axis. It should be noted that

$$\phi_R = \phi_L , \tag{1}$$

$$\theta_R = \theta_L \tag{2}$$

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and for small values of ϕ

$$\rho R = \rho L \ . \tag{3}$$

(2) The position of the image P′ of P in visual space can be specified with respect to the x′, y′ and z′ axes which correspond to the x, y and z axes of physical space. The center of projection lies at the origin. The direction of projection of the image P′ can be specified by giving the angles of elevation θ' and azimuth ϕ'. An essential part of the theory is that

$$\phi' = \phi \tag{4}$$

and

$$\theta' = \theta \ . \tag{5}$$

For small values of ϕ and θ the perceived distance ρ' is given by the following equation:

$$\frac{1}{\rho'} = \frac{1}{\rho} + k \tag{6}$$

where k is a constant. This applies to judgments of distance based on geometrical perspective as well as stereo cues. When ρ is infinite, $1/\rho = 0$ and $1/\rho' = k$. This means therefore that the constant k is equal to the reciprocal of the perceived distance of an infinitely distant object.

(3) Visual space is Euclidian and therefore in the case of a flat object normal or nearly normal to the line of sight, the ratio of its perceived linear size b' to its perceived distance ρ' is equal to its perceived angular size β' in radians.

$$\beta' = \frac{b'}{\rho'} \ . \tag{7}$$

(4) The perceived angular size (β') of an object is equal or very nearly equal to the angle (β) in physical space which it subtends at the entrance pupil.

$$\beta = \frac{\rho}{b} = \frac{\rho'}{b'} \tag{8}$$

where b is the physical size of the object and ρ is its distance from the entrance pupil of the eye.

It follows from Equations (6) and (8) that

$$b' = b/(1 + k\rho) \ . \tag{9}$$

The validity of this theory can be tested by adjusting the size of a comparison object such as a disc or square at a fixed distance from the eye or eyes to make it appear to match in size a standard object at a different distance. In making this adjustment the subject must avoid

estimating the size of either object from known facts about the situation: he must base his judgment strictly on the direct impressions of the sizes of the two objects. Mentally the subject can visualize his arm as being long enough to reach out and touch either of the two objects. He imagines that he reaches out and puts his forefinger and thumb on opposite edges of the standard object and then without changing the distance between his forefinger and thumb, he mentally moves his hand over to the comparison object and adjusts its size until it subtends the distance between his forefinger and thumb.

The attitude of the subject on this experiment differs from that of the artist who draws the different objects in his picture so that they will subtend at the eye the same relative angles with respect to each other as their counterparts in physical space. In this experiment, the subject aims to reproduce linear size, not angular size.

If we use the subscripts 1 and 2 to designate the symbols that apply to the standard and comparison objects,

$$b'_1 = b_1 / (1 + k_1 \rho_1) \tag{10}$$

and

$$b'_2 = b_2 / (1 + k_2 \rho_2). \tag{11}$$

When b_2 is adjusted to make

$$b'_1 = b'_2, \tag{12}$$

$$\frac{b_2}{b_1} = \frac{1 + k_2 \rho_2}{1 + k_1 \rho_1}.$$

Gilinski[2] has shown that Boring's data involving a match in apparent size between an adjustable comparison disc at 10 ft. and standard discs of constant angular size but placed at various distances conform to Equation (12) when k_2 is assumed to be equal to k_1 and is constant for different values of ρ_1. The value of k_1 and k_2 was found to be 0.00412 for binocular vision and 0.00758 for monocular vision, when ρ_2 and ρ_1 are expressed in feet.

Renshaw[3] has presented a set of data, Table I, for the size of an adjustable square at arm's length which is adjusted to make it match a standard white square (30 cm. on each side) mounted on a post which can be set at various distances from the observer. The experiment was carried out on a polo field. The distance of the comparison square from the eyes has not been specified. The exact value of this distance is not necessary, but it is within arm's reach and in the treatment of the data below it will be assumed to be equal to 0.5 meter.

TABLE I.
Renshaw's data on the relation of distance to perceived size.

ρ_1 (meters)	Log b_2^2	b_2 (millimeter)	$\frac{1}{b_2}$
3	4.832	260	.00384
6	4.777	243	.00412
12	4.696	222	.00450
24	4.642	209	.00478
48	4.513	181	.00552

Renshaw[3] has presented his data in the form of a graph in which the log of b_2^2 is plotted against the log of ρ_1. The values of log b_2^2 for various values of ρ_1 as taken from the graph are presented in Table I along with the computed values of b_2 and $1/b_2$.

The data are replotted in Figure 2. This method of plotting is convenient because it permits Equation (12) to be plotted as a straight

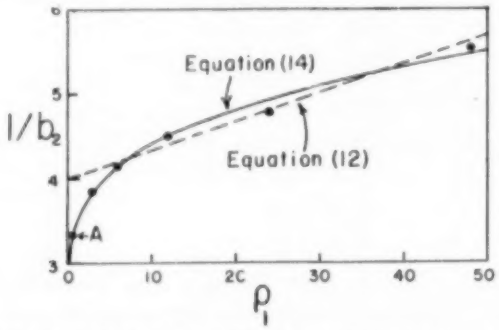

Fig. 2. Renshaw's data showing the relation of the perceived size to the physical distance of an object. b_2 and ρ_1 are both expressed in meters.

line, if k_1 is a constant for various values of ρ_1. Also if k_1 is equal to k_2, the straight line representing Equation (12) must pass through the point (A) which represents the value ρ_1 at which it is equal to ρ_2 and the value of b_2 at which it is equal to b_1. When the standard object is at the same distance as the comparison object, the two should appear the same size when they are actually the same size. It is obvious that the data do not conform to a straight line through A.

The straight line in Figure 2 represents a reasonably good fit for the data, but since this line does not pass through A, k_2 differs from k_1: $k_1 = .0085$ and $k_2 = -.333$ when b_1, b_2 and ρ_1 are all expressed in meters. It is not very likely however that k_2 can be a minus quantity.

One way out of the dilemma is to assume that k is a function of ρ. That is to say, one might assume that k changes as the eyes switch convergence and attention from one object to another. For example, let it be assumed that

$$k = \rho^{-.9} = \frac{1}{\rho^{.9}}; \tag{13}$$

Equation (12) reduces to

$$\frac{1}{b_2} = \frac{1}{b_1}\left(\frac{\rho_1}{\rho_2}\right)^{0.1}. \tag{14}$$

This is equivalent to the equation which Renshaw used to express the data.

Another way out of the dilemma is to suppose that the comparison between the perceived size of an object at, say, 48 meters with the perceived size of an object at 0.5 meter is too much for a subject, and he ends by making a compromise between equating visual angles and equating linear sizes.

SUMMARY

A theory of the relation between perceived size and distance presented in a previous paper is found to conform to Gilinsky's analysis of Boring's data. Renshaw's data, however, do not conform to the theory. Two possible explanations of the discrepancy have been suggested.

REFERENCES

[1]G. A. Fry, Visual Perception of Space, Am. J. of Optom., 27, 531-553 (1950).
[2]A. S. Gillinsky, Perceived Size and Distance in Visual Space, Psych. Rev., 58, 460-482 (1951).
[3]S. Renshaw, Psychological Optics (Optom. Ext. Program, Duncan, Okla.) Vol. II, Nos. 7 and 8, (May and June, 1951).

ACADEMY COMMITTEE APPOINTMENTS FOR 1953

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AN INVESTIGATION OF THE TIME CHARACTERISTICS OF ACCOMMODATION AND CONVERGENCE OF THE EYES*

HISTORICAL REVIEW

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A. PHYSIOLOGICAL APPROACH TO THE TIME RELATIONS OF ACCOMMODATION AND CONVERGENCE

The following is a review of some of the literature pertaining to the time characteristics of the internal rectus muscle and of the literature which might have some possible bearing upon the time characteristics of the ciliary body and the accommodative response.

Cooper and Eccles[3] have given 7.5 sigma as the contraction time of the internal rectus. This is quite a fast acting muscle compared to 23 to 40 sigma for white or pale muscle. It is very probable that the latent period of the internal rectus is of the order of 1 sigma.[4]

Direct information of the type just given for the internal rectus is not available for the iris or the ciliary body. The following is a brief review of the literature on the muscle physiology and histology of the ciliary body.

Eustachius, according to Duke-Elder,[5] first described the ciliary muscle in one of his "plates" (1552-74). Knox[6] studied the anatomy of the muscle with respect to accommodation in 1823. Waller[7] described the microscopic structure of the muscle in 1835. The meridional fibers of the muscle however usually bear the name of *Brücke's* muscle from an article published in 1846 by Brücke.[8] Similarly the circular fibers described earlier by Waller[7] (1835) bear the name of *Müllers muscle* even though Müller[9] did not publish until 1855.

Hensen and Völckers[10] (1876, 1878) studied the activity of the human ciliary muscle of a freshly enucleated eye. They pierced the sclera with a needle and observed that the needle moved backward on stimulation of the eye, the same as it had been seen to do in animals.

Jessop[11] described the ciliary muscle in considerable detail discussing its innervation and type of muscle. He also cited experiments to show that the activities of the iris and ciliary body can be carried on without any dependence upon the hydraulics of blood pressure. However, he

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did entertain the idea of a secondary blood vascular effect upon both the ciilary body and the iris.

Beer[12] (1894) did much on animal eyes and at one point actually recorded the accommodative response of a fish eye by means of a kymograph. The technique took advantage of the lateral shift of the lens by inserting a needle through the cornea into it. This needle was brought to rest on a rotating smoked drum and the eye was electrically stimulated. His record shows a latent period of approximately 0.5 second. This is the only instance discovered by the author in which the ciliary muscle response was recorded.

Hess and Heine[13] (1898) repeated Hensen and Völckers experiment also using a human eye. They cut a small hole through the sclera into the vitreous to determine whether or not any pressure increase occurs on accommodation. They concluded that no such increase in pressure occurs, a view which has generally been held to the present time.

Sachs[14] (1942) has attempted to measure the force of contraction of the ciliary muscle by hooking a solenoid armature to the choroid through an open section in the sclera. He then determined the force required to maintain the choroid immobile during a ciliary muscle contraction by measuring the current supplied to the solenoid. He found that frequently 200 milligrams of force were not adequate to prevent movement of the choroid at the equator. He reported also that the maximum observed shift of the choroid was 0.5 milimeter. With the aid of a stop watch he observed that 5 seconds in the dog and 3 seconds in the cat are required to complete the movement of the choroid during stimulation of the eye. The time required for relaxation is described by the term "instantly."

Allen[39] electrically stimulated the short ciliary nerves and recorded the response of the ciliary muscle of an enucleated dog's eye. He pierced the eye at its equator with a finely drawn glass needle and used a smoke drum to record the movements of the protruding end of the needle. The shapes of the response curves he obtained resemble those of striated muscle tissue except that the time required for the ciliary muscle response was much greater. He concluded that the ciliary muscle of the dog is multi-unit smooth muscle with a probable latent period of 0.1 to 0.25 second.

The remainder of the studies on the ciliary body have been mostly directed at determining the type and course of its innervation. The works of Fuchs (1928),[15] Statler (1937),[16] Clark (1937),[17] Cogan (1937),[18] Olmstead and Morgan (1941),[19] Morgan (1944),[20] Morgan (1946)[21] and others are representative of this type of study.

B. HUMAN EXPERIMENTATION

1. Reaction Time Experiments

Völkmann[22] is given the credit (Barrett[23]) for being the first to study the time characteristics of accommodation. He claimed to change the focus of his eye from 11 to 6 inches and back twenty times per minute using needles as accommodation targets.

Vierordt[24] used a chronoscope and viewed threads at variable distances. He attempted to initiate nervous impulses to accommodation and to the hand at the same time to record the start of the accommodative act. This would automatically correct for the reaction time of the manual response used to register the end of the accommodative act, at least in so far as the time delay from the cortex to the hand is concerned. He gives us a ratio of 125/100 for the time required to accommodate from far to near as compared to that from near to far.

Aeby[25] used a response key and recorded directly on a smoked cylinder. He used needles at various near distances as accommodation targets and reported a ratio of 150/100 for the time required to accommodate from far to near as compared to that from near to far.

Barrett[23] used an optical system for controlling the accommodative stimulus and recorded the beginning and end of the accommodative act by pressing a key. He found all relaxation times immeasurably short except that of three diopters which he found to be 0.7 seconds. In attempting a deductive evaluation of the latent period of the ciliary muscle he says: ". . . it is only from analogy that the ciliary muscle has a latent period."[26]

All of the above studies have contained the hand reaction time of the subject as an important and variable error. The following methods have largely been successful in eliminating this error by resorting to a tachistoscopic approach. This technique first used by Ferree and Rand[27] has been used by such investigators as Bannister and Pollock,[28] Robertson,[29] Leukart[30] and others. The method is essentially that of exposing far and near targets in serial order and at such a speed that the subject is barely able to keep up.

Travis[31] using a drop frame tachistoscope has purposely retained the subject's reaction time and the time to report what was seen as an integral part of the act of seeing from far to near, etc. He felt that the components are not as important as the total act.

2. Photographic Experiments.

Kirchhof[2] has introduced an entirely new technique based on continuous photography of the third Purkinje image (Purkinje-Sanson) during changes in accommodation. He used three subjects and studied

the effects of various drugs and of fatigue. He found a ratio of 117/100 for far to near accommodation time compared to near to far accommodation time. The average accommodation time for a 6.5 diopter level was 0.426 second. This time does not include the reaction time of the subject, that is, Kirchhof measured from the inflection point at the beginning of the accommodative record to the final inflection point where all changes in accommodation had ceased. The latest work of this sort is being carried on in France by Marandon[32].

Recording convergence has been almost as delayed in achievement, as has the recording of accommodation. Woodworth[33] attributes the first successful recording of convergence to Delabarre (1898) and Huey (1908). They attached a kymograph writing lever to the eye by means of a small ring of plaster of Paris and recorded directly on a smoked drum.

Dodge and Cline (1901)[34] first used photography on a moving film for continuous recording of the corneal reflex (the first Purkinje image)[1] which moves when the eye is rotated, thus giving a means for studying convergence and other eye movements.

With this and other techniques and modifications, Dodge[35] obtained the following figures. The reaction time for compensating an involuntary head movement is 50 sigma. The reaction time for compensating a voluntary head movement is less than 16 sigma. The reaction time for pursuit movement is 200 sigma. The reaction time for a saccadic refixation is 195 sigma.

Stratton[36] first used the technique of recording fixation movements on a stationary film which makes possible a later projection of the eye movements back onto the material used to induce the eye movements. Time studies with this type of equipment are impractical.

Judd (1907)[37] studied convergence and divergence using a motion picture camera which is undoubtedly more difficult to work with than is the method of Dodge.

Clark[38] photographically recorded both vertical and horizontal components of changes from far to near using a target changing at a rate of 70 per minute. The near target was at 33 cm. and the far target at 244 cm. Data were taken both monocularly and binocularly. The results are given as the upper and lower time limits observed in a number of trials but in general it appears that divergence is slower than convergence.

REFERENCES

[1]Duke Elder, Sir W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 735.

[2]Kirchhof, von Hermann. "Eine Methode zur objektiven Messung der Akkommodationsgeschwindkeit des Menschlichen Auges." Zeitschrift fur Biologie, Vol. 100 (1940), pp. 408-20.

[3]Cooper, S. and Eccles, J. C. "The Isometric Response of Mammalian Muscles." Journal of Physiology, Vol. 69, (1930), pp. 377-385.
[4]Bard, Philip. Macleod's Physiology in Modern Medicine. St. Louis: C. V. Mosby Company, 1941. p. 16.
[5]Duke Elder, Sir. W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 61.
[6]Knox. "The Comparative Anatomy of the Eye." Royal Society of Edinburg, June 17, 1823. (From Duke Elder, Sir. W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 61.)
[7]Waller, W. C. American Journal of Science and Arts, Vol. 27, (1835), p. 219. (From Duke Elder, Sir. W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 61.)
[8]Brucke. "Eine Neuer Muskel in Auge." Med. Zeit., Vol. 15 (1846), p. 130. (From Duke Elder, Sir. W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 61.)
[9]Müller, H. Phys.-Med. Ges., Wurzburg, Nov. 24, 1855. (From Duke Elder, Sir. W. Stewart. Text-Book of Ophthalmology. St. Louis: C. V. Mosby Company, Vol. 1, 1946, p. 61.)
[10]Hensen, V. and Völkers, C. "Ueber die Accommodationsbewegung der Chorioidea im Auge des Menschen, des Assen und der Katze." Albrecht von Graefe's Archives für Ophthalmologie, Vol. 19 (1), (1876), pp. 156-162.
[11]Jessop, M. "Anatomy, Physiology and Histology of the Intraocular Muscles of Mammals." Proceedings of the Royal Society, Vol. 40, (1886), p. 478.
[12]Beer, Theodor. "Die Accommodation des Fischauges." Archiv für die Gesamte Physiologie des Menschen und die Tierre. Vol. LVIII, (1894), p. 569.
[13]Hess, C. and Heine, L. "Experimental Untersuchungen über den Einfluss der Akkommodation auf den intraocularen Druck, nebst Beiträgen Kenntnis der Akkommodation bei Säugetieren." Archives f. Ophthalmologie. Vol. 46, (1898), pp. 243-276.
[14]Sachs, E. "Observations and Experimental Studies on the Physiology of the Ciliary Muscle." American Journal of Ophthalmology, Vol. 25, (Nov. 1942), pp. 1277-1291.
[15]Fuchs, E. "Uber den Ciliarmuskel," Graefes Archives f. Ophthalmologie, Vol. 120, (1928), p. 733.
[16]Statler. "Innervation of the Intrinsic Muscle of the Eye: An Experimental Study." Proc. Soc. Exp. Biology, N. Y., Vol. 36, (1937), pp. 576-577.
[17]Clark, Sam L. "Innervation of the Intrinsic Muscles of the Eye of the Cat." Journal Comparative Neurology, Vol. 66, No. 2 (1937).
[18]Cogan, D. N. "Accommodation and the Antonomic Nervous System." Archives of Ophthalmology, Vol. 18, (1937), p. 739.
[19]Olmstead, J. M., and Morgan, M. W. Jr., "Influence of the Cervical Sympathetic Nerve on the Lens of the Eye." American Journal of Physiology, Vol. 133, (July, 1941), pp. 720-723.
[20]Morgan, M. W. Jr., "The Nervous Control of Accommodation." American Journal of Optometry, Vol. 21, (March, 1944), pp. 87-93.
[21]Morgan, M. W. Jr., "New Theory for the Control of Accommodation." American Journal of Optometry, Vol. 23, (March, 1946), No. 3, p. 99.
[22]Volkmann. "Study of Time Relationship of Accommodative Process." Arch. of Physiologie, Heilkunde n.f. Vol. 1, (1857), p. 17.
[23]Barrett, James W., "Velocity of Accommodation." Journal of Physiology, Vol. VI, (1885), pp. 46-70.
[24]Vierordt. "Versuche über die Zeitverhältnisse des Accommodationsvorgang im Auge." Arch. f. Physiologie, Heilkunde, N. F. Vol. 1, (1857).
[25]Aeby. "Accommodative Speed of Human Eyes." (Henle and Pfeufers) Zeitschrift für Rationelle Medicin, III Reihe, Vol. XI, (1861), p. 300.
[26]Barret, James W., "Velocity of Accommodation." Journal of Physiology, Vol. 6, (1885), p. 58.
[27]Ferree, C. E., and Rand, G., "The Inertia of the Adjustment of the Eye for Clear Seeing at Different Distances." American Journal of Ophthalmology, Vol. 1, (1918), pp. 764-776.
[28]Banister, H., and Pollock, K. G. "The Accommodation Time of the Eye." British Journal of Psychology, Vol. 19, (1929), pp. 394-396.

[29]Robertson. C. J. Archives of Ophthalmology. Vol. 14. (1935). p. 82: Vol. 15. (1936). p. 423: Vol. 17. (1937). p. 859.
[30]Leukart. R. H. Journal Experimental Psychology. Vol. 25. (1939). p. 257.
[31]Travis. Roland C. Journal Experimental Psycholgy. Vol. 38. (1948). p. 395.
[32]Marandon. Janine. "Sur Une Nouvelle Methode D'Etude des Reactions Cristalliniennes Aux Différente Mydriatiques." Revue D'Optique. Vol. 28. No. 3. (March. 1949). pp. 146-151.
[33]Woodworth. R. S. Experimental Psychology. New York: Henry Holt and Company. 1938. p. 578.
[34]Dodge. R.. and Cline. T. S. Psychological Review. Vol. VIII. (1901). pp. 145-157.
[35]Dodge. R. "Latent Time of Compensatory Movements." Journal of Experimental Psychology. Vol. 4. (1921). pp. 247-269.
[36]Stratton. G. M. Wundt's Phil. Stud.. Vol. XX. (1902). b. pp. 336-359.
[37]Judd. C. H. "Photographic Measures of Convergence and Divergence." Psychological Monograph. Vol. 8. No. 34. (1907). pp. 370-435.
[38]Clark. Brant. "Photographic Measures of Accommodative Convergence." American Journal of Optometry. Vol. 10. (1933). p. 120.
[39]Allen. M. J. "The Response of the Intra-Ocular Muscles of the Dog and Cat to Electrical Stimulation." American Journal of Optometry. 27. 6. 1950.

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Since our last annual meeting the Academy has lost seven of its members through death. Each of these men played a significant part in the development of the profession and each by his splendid work has left his important mark on the present and future of optometry. All have been active in the Academy. We indeed miss these important leaders and the membership of the Academy at this time pays tribute to them.

(From the minutes of the Rochester, New York, meeting of the Academy.)

EFFECTIVITY OF PRISMS AT NEAR*

Joseph I. Pascal†
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The changed effectivity of a lens at near is pretty well known to all ophthalmic practitioners. Relatively few, however, are aware of a similar change in effectivity in prisms.

If, say, a 10Δ prism is placed base down before an eye looking at a distant target, the eye will deviate upward in order to resume fixation. The rotation of the eye, expressed in prism diopters (delta), will equal to the power of the prism, that is the eye will turn up to the extent of 10Δ. Although the prism is some 25 mm. in front of the center of rotation of the eye, there is no change in the effectivity of the prism at distance. Similarly, a 5Δ prism will cause an ocular rotation of 5Δ, a 15Δ prism will cause an ocular rotation of 15Δ and so on. This, it may be noted, is quite different from what takes place with spherical and cylindrical lenses, where because of the separation of lens and eye, there is an altered effectivity at distance, which gives us, what is often referred to, as the "spectacle" correction as against the "true" correction of ametropia.

However, when we come to near vision we find that the prism at near does have an altered effectivity. It loses in effect. The loss is dependent upon two distances, the distance of the prism from the center of rotation of the eye, call it "d" and the distance of the object from the eye, i.e., its location, call it "*l*". Thus if d = 25 mm. and *l* = 40 cm. (400 mm.) the loss in prism power or rather in effectivity is $\frac{25}{400}$ of 10 = 0.63Δ. That is, the effect of the 10Δ prism is only 9.37Δ, (10 — 0.63).

This loss of effectivity, it should be remembered, refers to the lessened rotation of the eye behind the prism. That is, a 10Δ prism produces a turning of the eye of only 9.37Δ. Let EΔ (read E delta) stand for the rotation of the eye expressed in prism diopters, PΔ for the power of the prism, d and *l* for the distances of the prism and the object from the center of rotation of the eye respectively, then we can say

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$E\Delta = P\Delta - \frac{d}{l} \times P\Delta$. That is, the deviation of the eye is equal to the deviation caused by the prism less a fraction $\frac{d}{l}$ of the power of the prism.

We can obtain a percentage relation for the loss of effectivity for any distance or location "*l*" of the object. Say object is 40 cm. from the eye, "d" can be taken generally as 25 mm., the percentage relation is $\frac{2500}{400}$, which gives 6.25%. If the object is at 35 cm., $l = 35$ cm., this gives a loss of about $7\%\left(\frac{2500}{350}\right)$. If the object is at 30 cm., the percentage loss is about $8\%\left(\frac{2500}{300}\right)$, object at 25 cm. gives a percentage loss of about $10\%\left(\frac{2500}{250}\right)$, and object at 20 cm. gives a percentage loss of $12.5\%\left(\frac{2500}{200}\right)$.

In other words, for objects at the ordinary near distances the percentage loss in effectivity is about 6% or 7%. For objects real close to the eye the percentage loss is some 10% or 12%. But the loss can be figured out easily from the fraction. The further the prism is from the eye the greater the loss since the fraction $\frac{100\ d}{l}$ increases as d increases. Thus for an extreme case of a prism held 5 cm. from the eye while viewing an object 25 cm. from the eye, the loss is 2/10 or 20% of the prism power. This method, while not rigorously accurate, is very, very close, and sufficient for all purposes

SUMMARY

A prism when used at near causes a deviation of the eye which is less than corresponds to its power. If d and *l* stand for the distances from the eye of prism and object respectively, then the percentage loss in effectivity equals $\frac{100\ d}{l}$. This amounts to about 6% or 7% of the prism power for ordinary reading distances and to about 10% to 12% for very close distances.

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SPACE EIKONOMETRY IN ANISEIKONIA*

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I. INTRODUCTION

Beginning in 1928, Ames and his co-workers at Dartmouth College devised means of measuring small differences in the relative size of the ocular images. The first instruments consisted of a haploscope device which was later supplanted by the Ophthalmo-Eikonometer and then the Simplified Eikonometer. These instruments provided a direct *linear* comparison and measurement of relative ocular image size in the horizontal and vertical meridians while single binocular vision was maintained by means of a central fusion target. Previous papers[1] have described these early instruments as well as the techniques gradually established by research and clinical experience. The theoretical aspects[2] and the clinical results[3] of aniseikonic corrections determined by means of these instruments for several thousand patients have also been presented in the ophthalmic literature during the past twenty years.

Some criticisms, mostly on theoretical grounds and without the support of clinical data, have been expressed regarding the nature of the measurements obtained by the direct linear comparison method. It was claimed that peripheral fusion, a prerequisite to the test, was unreliable; that heterophoria or anisophoria was measured instead of aniseikonia; and that asymmetric convergence invalidated the measurements. Lancaster[4] disposed of these criticisms in his typical lucid manner. Furthermore, the development of means of measuring disparities in image size by their effect upon binocular space perception provided convincing evidence that aniseikonia is a measurable entity distinct from heterophoria, anisophoria, and asymmetric convergence.

II. SPACE PERCEPTION AND ANISEIKONIA

It was recognized in the early researches at Dartmouth that small (1% or less) relative differences, or *disparities*, in ocular image size could be detected by their influence upon binocular space perception. In fact, even prior to the Dartmouth studies, it was pointed out by Wadsworth[5] (1876), Culbertson[6] (1888), and Lippincott[7] (1889) that

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the correction of astigmatism produced distortion in space perception. In 1889, Green[8] was the first to interpret the phenomenon as resulting from the changed disparities between the retinal images. However, these disclosures received no serious clinical attention until the Dartmouth investigation provided practical means of measuring and correcting such disparities in image size.

Figure 1 indicates how a disparity in the horizontal meridian, caused by a plano magnifying (size) lens, affects the apparent position

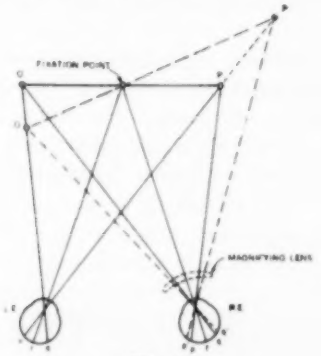

Fig. 1

of a frontal plane, QP. Before the magnifying lens is interposed before the right eye, points Q and P have retinal images at q and p. The magnifying lens causes an increase in the size of the image and the images of Q and P now fall on the retina at q′ and p′. The disparity of the images has been changed so that the binocular (stereoscopic) response is as though the points Q and P were located in space at Q′ and P′.

It should be borne in mind that the perception of space is based upon two factors—empirical *monocular* clues and *binocular* (stereoscopic) clues. The former includes known form, overlay, light and shade, known size, parallax and related perspective clues. It is generally recognized that these clues are learned by experience and practice. Stereoscopic vision, which is the visual experience of depth resulting from the disparities between the images received by the two eyes, is an innate faculty. Aniseikonia affects the apparent localization of space as experienced by *stereoscopic* vision. This distinction between non-stereoscopic and stereoscopic factors in space perception is elaborated upon in a previous paper.[9]

As mentioned before, the Dartmouth group recognized the relationship between differences in the size of the images in the two eyes and an

incorrect binocular spatial localization. Ames invented means of determining these image size differences on the basis of the type and the degree of the associated apparent spatial distortions. The Space Eikonometer is the result of this research. Earlier instruments depending upon apparent spatial distortions included the horopter apparatus,[10] "the tilting boards"[11] and the "leaf room."[12] All these proved clinically inadequate. The horopter apparatus measures image size differences only in the horizontal meridian, and neither the "tilting board" nor the "leaf room" permit precise differentiation of vertical and horizontal size differences.

The Space Eikonometer, by utilizing apparent spatial distortions, provides for the measurement of the complete aniseikonic error including magnification differences in oblique meridians. Three independent measurements are made—the horizontal and vertical components of the aniseikonia, and the vertical declination which occurs when a meridional aniseikonia is present at an oblique axis.

III. THE SPACE EIKONOMETER

The essential parts (Figure 2) of the original Space Eikonometer[13] were: (1) a system of selected test elements: (2) special test magnifying

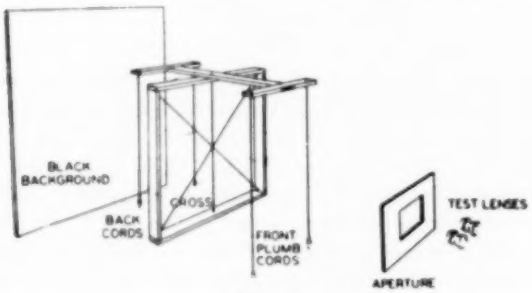

Fig. 2

lens units, by means of which the size of the images in the two eyes can be changed optically: and (3) a head rest. The test elements consisted of: (a) an oblique cross made up of two smooth red cords stretched at right angles to each other from opposite corners of a 5 foot square frame, and (b) two pairs of smooth vertical plumb cords—a green pair 2 feet in front and a white pair 2 feet behind the cross. The plane of the cross was carefully erected at right angles to the subject's objective median and visual (horizontal) planes. A white plumb line was suspended in the plane of the cross and through its center.

The green cords were separated laterally approximately 20 inches

and thus subtended a visual angle of about 12 degrees at the observer's eye at a distance of 10 feet. These cords were equidistant from the subject's objective median plane, and the plane of each pair of cords was parallel to his frontal plane. The subject's binocular field of view was restricted to the test elements by suitable apertures, which also prevented him from seeing the ends of the cords. Colored cords were used merely for easier identification of the various parts of the test configuration. The cords were seen on a uniformly black background, four tubular lamps providing shadowless illumination. The original model of the Space Eikonometer required a rather large room—at least, 10x20 feet—which made it impractical for the average office. Hence, a more compact instrument that would occupy a minimum of office area had to be developed.

In the new office-model Space Eikonometer, the target described above is replaced by two photographic transparencies of the test elements mounted in a suitable housing before the eyes. A septum dissociates the target seen by the right eye from that seen by the left. Fusion of the two images causes the test elements to appear stereoscopically.

The instrument is small and compact, occupying table space of

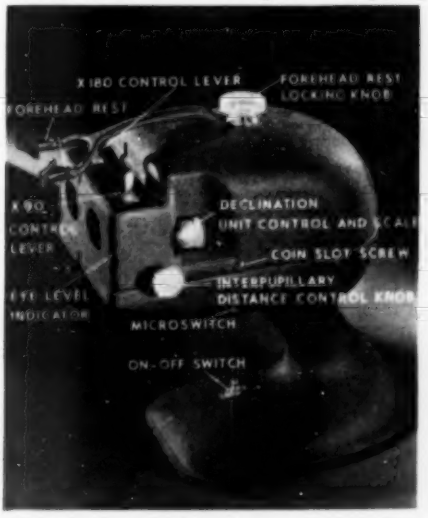

Fig. 3

only 7 in. x 10 in. Figure 3 depicts the essential elements. It provides measurements of three quantities:

1. The horizontal (ax. 90) image size difference.

2. The vertical (ax. 180) image size difference.
3. The declination (δ) in degrees—that is, the apparent inclination or disclination of the binocularly perceived vertical. A declination error exists when there are meridional size differences in oblique meridians.

The eikonic targets (Figure 4) consist of Kodachrome transparencies before each eye so designed as to give a three-dimensional

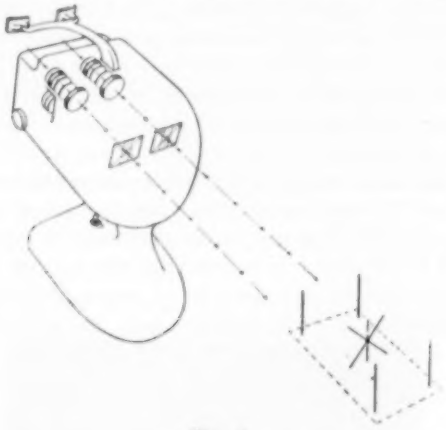

Fig. 4

representation of five vertical lines and an oblique cross in space—very much the same as that seen in the original Space Eikonometer (Figure 2). Projection lenses of about +6.00 D. power project the image of the test target optically to a distance of about 10 feet from the eye.

The optical unit (Figure 5) before the right eye is the ax. 90 unit, controlling magnification in the horizontal meridian. The optical

Fig. 5

unit before the left eye is the ax. 180 unit, controlling magnification in the vertical meridian. The declination size lens unit consists of a matched pair of meridional magnifiers mounted, one before each eye, in such a way that they can be rotated by equal but opposite amounts. With these lenses the declination error is measured by introducing an equal declination in the opposite direction, without introducing any change in the horizontal or vertical meridians.

THE TECHNIQUE OF SPACE EIKONOMETRY

It is assumed that prior to the examination for aniseikonia the patient's history and symptoms are recorded; especially the *Chief Complaint* and whether this occurs in distant or near vision, or whether this complaint is at all associated with the use of the eyes. The onset, duration, and frequency of the symptoms are noted, as well as the means already used by the patient to obtain relief. Individual cases vary, of course, and make necessary modifications in the history taking, but it is very helpful to the examiner if he knows as much as possible about the patient's medical history and symptoms, so that in deciding on the justification of prescribing a correction for ametropia or aniseikonia, he will be guided not only by the measurements he has taken, but also by the nature of the patient's symptoms.

The patient's distance ametropia is corrected by trial case lenses placed in a trial frame that is properly centered and adjusted so that the spherical lenses are 13.75 mm. from the apex of the cornea. It is necessary to use either Tillyer or Orthogon trial case lenses if a final aniseikonic correction in single lens (permanent) form is desired since the magnifying properties of these lenses are known. The magnifying properties of other trial case lenses have not been determined and hence it is impossible to design aniseikonic corrections based upon such lenses. It is possible to use the patient's correction in spectacle lens form and to design aniseikonic lenses if certain characteristics (curves, thicknesses, lens size, vertex distance, etc.) are given.

Since the Space Eikonometer test depends upon binocular (stereoscopic) vision, it is obvious that only those patients who have simultaneous binocular vision and stereopsis can be tested. Although aniseikonia may be a factor in strabismic cases, such patients cannot be tested on the Space Eikonometer unless they can obtain fusion and stereopsis by means of orthoptics, prisms and/or surgery. Furthermore, the details of the Space Eikonometer test elements are such that a visual acuity of at least 20/60 with each eye is necessary. Finally, the patients must have a certain degree of intelligence in order to understand the questions asked; to make the necessary observations; and, to give

unequivocal replies. This does not mean that a great deal of intelligence is required, but at least equivalent to that of a normal six-year-old child.

Once the patient's distance ametropia is corrected as described above and the other requirements are fulfilled, the patient is directed to place his forehead against the forehead rest of the instrument and look into the instrument. The illumination for the targets having been turned on and the interpupillary distance (P.D.) of the instrument adjusted to correspond to that of the patient's, the examiner covers first one, then the other, of the patient's eyes with an occluder provided with the instrument. When one eye (and then the other) is covered, the examiner asks the patient if he sees the five vertical lines (the words "rods," "posts," "sticks," may be substituted for "lines"; also the phrase "up and down" may be used instead of "vertical") and, also, does he see the oblique cross or X. This quick preliminary step serves two purposes. It acquaints the patient with what he is supposed to see—gives him a descriptive name for the test elements—and it checks on whether or not each eye is properly centered so as to permit a view of the entire field for each eye. If, for example, the patient reports that with one eye he sees only four (instead of five) vertical lines, his head is moved laterally very slightly until he does see five vertical lines.

Following the above procedure of being sure that the patient sees the entire target with each eye, the examiner asks the patient if he notices that the green verical lines are in front of the red cross and the yellow vertical lines are behind the red cross, and, also, that the entire target appears to be quite far away—about 10 feet. It has been found that if the back of the instrument is close to a wall of the examining room, some patients will report that the target appears to be no further away than the wall. However, if the instrument is so placed that there is considerable distance (10 to 20 feet) behind it, the target will more readily be seen at a greater distance.

It may take a few seconds for some patients to get the proper and complete stereoscopic effect much as it does with stereoscopic cards in a hand stereoscope. A demonstration of the marked effect upon the target of a large size difference—first, R 4% x 90 and then L 4% x 90—will help in bringing out the depth effect and in showing what kind of judgments are required. Following these preliminary steps which are really very important but which take more time to describe than it does to do them, the actual testing may be started. A "zero reading"—with all the measuring units set at zero—is taken by simply asking the patient if the right or left vertical lines appear closer to him.

When a difference exists in the size of the ocular images in the two eyes in the *horizontal* meridian only (Figure 6), one of each pair

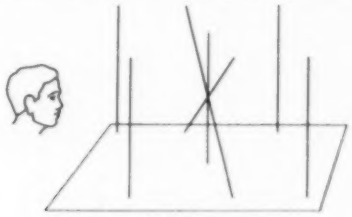

Fig. 6

of the vertical lines will appear nearer the subject than does the other. The oblique cross will also appear rotated about a vertical axis. The nearer vertical line and the nearer side of the cross will be on the side of the eye having the smaller ocular image. By increasing the size of the image in that eye in the horizontal meridian by means of the appropriate adjustment of the magnifying test lens unit, the vertical lines and the two sides of the cross can be made to appear equidistant from the observer.

If a difference in the size of the ocular images exists in the *vertical* meridian only (Figure 7), the cross alone will appear rotated about a

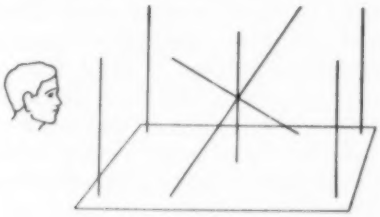

Fig. 7

vertical axis (the vertical lines will be unaffected), the farther side being on the side of the eye having the smaller image. By magnifying the image in that eye in the vertical meridian by means of the appropriate adjustment in the test lens unit, the two sides of the cross can be made to appear equidistant from the patient, i.e., fronto-parallel. Thus, the presence and magnitude of a horizontal and a vertical image size difference can be detected and measured by the difference in distance of the vertical lines and by the apparent rotation of the cross. When both horizontal and vertical image size differences exist, the horizontal one should be corrected first.

If a meridional image size difference is present at an oblique axis

(Figure 8), so that there is a resulting declination error between the ocular images of vertical lines, then the plane of the cross appears

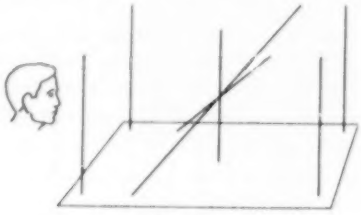

Fig. 8

inclined (as though rotated about a horizontal axis through the center of the cross). If the upper part appears inclined away from the observer, the axes of the correcting meridional size lenses must be rotated so as to converge upward in order to correct that inclination. The measured declination error, δ, has been taken arbitrarily as positive in this case. If the upper part of the cross appears inclined toward the patient, the measured declination error is negative and the axes of the correcting meridional size lenses must be rotated so as to converge downward. By rotating the geared lenses by the proper amount and in the proper direction, the apparent inclination of the plane of the cross can be varied until it appears in the same plane with the vertical plumb line through the center of the cross. The degree of rotation of the geared lenses measures the vertical declination error. The final result of the total aniseikonic error is determined by correcting in sequence the horizontal and the vertical image size differences and then by correcting the declination errors, since the incorrect apparent orientation of any one of the test elements during the test may affect the relative position of the others unless done this way.

The data are obtained by questioning the patient regarding the apparent positions of the test elements while the examiner changes the adjustments of the test lenses. As with the standard (direct comparison) eikonometer, the "method of limits" within which the test elements appear properly oriented is applied to obtain the final correction. The stereoscopic sensitivities of the patient to the three parts of the test are estimated by one-half the range within which he reports the vertical cords and the cross to be correctly oriented (Figure 9). By referring to prepared tables provided with the instrument, the final aniseikonic correction follows directly from the measurements. The clinician's decision to prescribe a full, partial, or no aniseikonic correction is based not only upon the measurements obtained but also upon his professional

Fig. 9

judgment and experience in much the same manner as are refractive and heterophoric corrections.

A number of patients have been tested on both the direct comparison eikonometer and the space eikonometer. Highly significant correlations of the data[14] obtained by these two methods indicate that both methods measure the same quantities accurately. Ogle[15] has presented in previous publications the theory of the Space Eikonometer. Other basic papers[16] on the Space Eikonometer have discussed the effect of astigmatism at oblique axes, the stereoscopic sensitivity in the Space Eikonometer, the influence of cyclofusional movements, and the agreement between distance and near measurements.

Over a hundred of the office model Space Eikonometers have been released to ophthalmic institutions and private practitioners. In general, clinical experience has indicated that the Space Eikonometer test for aniseikonia requires considerably less time and provides an easier discriminative task for most patients than does the standard eikonometer. However, in some instances, the additional data afforded by the measurements of a declination error has caused difficulties to the practitioners, the lens designer and manufacturer. When space eikonometry measurements indicate that the aniseikonia is in the direction expected from the anisometropia—especially, the axes of the meridional size correction correspond approximately to those of the astigmatic correction—the clinician has no difficulty in deciding what to prescribe and the lens designer and manufacturer have relatively little trouble in providing correcting lenses. It is when the aniseikonia measured differs radically from that expected on the basis of the anisometropia—particularly when the axes of the oblique meridional size correction are 20 degrees or more from the axes of the astigmatic correction—that the practitioner has difficulty in deciding what to prescribe and frequently the lens designer and manufacturer have considerable difficulty in providing correcting lenses. As mentioned before, increased clinical experience will assist in increasing the usefulness of space eikonometry data, especially with reference to the oblique aniseikonic error.

From a purely clinical viewpoint, space eikonometry provides a means whereby practitioners may investigate whether or not their patients' symptoms are related to ocular image size differences and space perception anomalies. It is not always necessary to prescribe an aniseikonic correction since practitioners may check their patients with a tentative refractive correction to determine if it introduces a significant aniseikonia and, in some cases, the refractive correction may be modified to minimize the aniseikonic error. In other instances, the full refractive correction providing optimum vision may be given if it does not introduce a significant aniseikonia or the aniseikonic factor may be corrected if it is significant. Besides knowing the visual acuity, heterophoria, fusional amplitudes, and other visual data relative to certain ametropic corrections, the practitioner may now know what effect such corrections have upon his patients' space perception and visual performance.

Although it is well known that some patients can tolerate, or become adjusted to, new refractive corrections which introduce distortions of space perception, it should not be concluded that there is a physiological compensation for disparities in the relative size of the ocular images. Repeated measurements[17] taken while wearing lenses which introduced a known amount of aniseikonia have shown substantially the same error even after the spatial distortions in familiar surroundings had disappeared. Hence, it may be concluded that unless aniseikonic errors are corrected, there will remain a basis for conflicts between the monocular and binocular judgments of space perception[9] as well as between the visual impression and the actual location of objects in space. These inefficiencies of visual function combined with the burden upon fusion and fusional movements of the eyes are believed to be sources of symptoms in some individuals.

SUMMARY

Instruments for measuring differences in the relative size of the ocular images (aniseikonia) were devised by Ames and his colleagues at Dartmouth College beginning in 1928.

It was recognized in the early researches that even small amounts (one percent or less) of these relative size differences (disparities) could be detected by their influence upon space perception. Following the clinical use of instrumentation which measured the *linear* difference in the relative size of the ocular images, the Space Eikonometer was developed which measures size differences indirectly, that is, by the effect such binocular disparities have on the subjective appearance of an appropriate target. An illustrated description of the new instrument and its operation is given.

The discomfort reported by patients with small differences in ocular image size may be due, in part, to the many fine exacting neuromuscular adjustments necessary to see singly and efficiently. This burden upon the fusion faculty may account for some symptoms but it is also likely that besides physiological factors, there are psychosomatic aspects which need further exploration.

As a refinement of refractive procedure, the routine measurement of aniseikonia depends not only upon available instrumentation and correcting lenses, but also upon the knowledge and interest of ophthalmic practitioners who are eager to render their patients the ultimate in efficient and comfortable vision.

REFERENCES

1. Ames, A., Jr., G. H. Gliddon, and K. N. Ogle: Size and Shape of Ocular Images. I. Methods of Determination and Physiologic Significance. Arch. Ophth., 7: 576-597, 1932.

   Madigan, L. F.: Examination and Correction of Aniseikonia. Arch. Ophth., 13 (4): 696-698 (April), 1934.

   Bannon, R. E.: On the Technique of Measuring and Correcting Aniseikonia. Am. J. Optom. & Arch. Am. Acad. Optom., 18 (4): 145-166 (April), 1941.

   Boeder, P.: Aniseikonia. Amer. Opt. Co., Southbridge, Massachusetts, 1941.

   Madigan, L. F.: The Measurement and Correction of Aniseikonia. Amer. Opt. Co., Southbridge, Massachusetts (January), 1942.

2. Ames, A., Jr., and K. N. Ogle: Size and Shape of Ocular Images. III. Visual Sensitivity to Differences in the Relative Size of the Ocular Images of the Two Eyes. Arch. Ophth., 7: 904-924, 1932.

   Ames, A., Jr., and Kenneth N. Ogle: The Horopter and Corresponding Retinal Points. Annals Disting'd Serv. Found. Optom. (1), 35-45, 1932.

   Ames, A., Jr., Gordon H. Gliddon, and Kenneth N. Ogle: Lenses for Changing the Size and Shape of Dioptric Images. Annals Disting'd Serv. Found. Optom. (1), 67-70, 1932.

   Ogle, K. N.: The Correction of Aniseikonia with Ophthalmic Lenses. J. O. S. A., 26 (8): 323-337 (August), 1936.

   Lancaster, W. B.: Nature, Scope and Significance of Aniseikonia. Arch. Ophth., 28 (5): 767-779 (November), 1942.

3. Madigan, Leo F., and Elmer H. Carleton: A Clinical Report on the Corrections of Differences in the Size and Shape of Ocular Images. Annals Disting'd Serv. Found. Optom. (1), 71-92, 1932.

   Hughes, W. L.: Report of a Series of Cases Examined on the Ophthalmo-Eikonometer. Arch. Ophth., 14: 146-159, 1935; Aniseikonia. Some Clinical Observations. Am. J. Ophth., 18: 607-615 (July), 1935; Aniseikonia in Emmetropia, Am. J. Ophth., 20: 887-890 (September), 1937.

   Bannon, R. E.: Heterophoria and Aniseikonia. Am. J. Optom., 16 (3): 96-109 (March), 1939.

   Berens, Conrad and Loutfallah, Michel: Aniseikonia: a Study of 836 Patients Examined With the Ophthalmo-Eikonometer. Am. J. Ophth., 22: 625-641 (June), 1939.

   Stoddard, K. B.: Aniseikonia. Am. J. Optom., 17 (6): 253-266 (June), 1940.

   Bannon, R. E.: Headaches and Aniseikonia. Am. J. Optom., 17 (10): 448-459 (October), 1940.

   Doane, H. C.: Analysis of Clinical Data on Aniseikonia with Case Reports. Am. J. of Optom. and Arch. of Am. Acad. of Optom., 18 (9): 393-403 (September), 1941.

Birge, H. L.: Aniseikonia—A Refinement of Refraction. Arch. Ophth., 27 (2): 357-360 (February), 1942.

Bannon, R. E.: Practical Aspects of Aniseikonia. Am. J. Optom. & Arch. Am. Acad. Optom., 19 (6): 239-256 (June), 1942.

Fisher, Harold M.: Aniseikonia in Routine Refraction. Am. J. Optom. & Arch. Am. Acad. Optom., 19 (12): 475-487 (December), 1942.

Burian, H. M.: Clinical Significance of Aniseikonia. Arch. Ophth., 29: 116-133 (January), 1943.

Hicks, A. M.: Aniseikonia. A Review of 200 Consecutive Cases Examined on the Eikonometer. Arch. Ophth., 30: 298-311 (September), 1943.

Cushman, B.: Analysis of Cases of Aniseikonia. Arch. Ophth., 33: 9-12; also Trans. Am. Ophth. Soc., 42, 1944.

Bannon, R. E. and W. Triller: Aniseikonia—A Clinical Report Covering a Ten Year Period. Am. J. Optom. & Arch. Am. Acad. Optom., 21 (5): 171-182 (May), 1944.

Post, L. T.: An Evaluation of Aniseikonia After Twelve Years. Am. J. Ophth., 29: 742-745 (July), 1946.

4. Lancaster, Walter B.: A Reply to Criticisms of Aniseikonia. Trans. Am. Ophth. Soc., 1942.

5. Wadsworth, O. F.: On the Effect of a Cylindrical Lens, With Vertical Axis Placed Before One Eye. Trans. Am. Ophth. Soc., 342-344, 1876.

6. Culbertson, H.: Binocular Astigmatism. Am. J. Ophth., (5), 117-123 (May), 1888.

7. Lippincott, J. A.: On the Binocular Metamorphosia Produced by Correcting Glasses. Arch. Ophth., (18), 18-30, 1889.

8. Green, J.: On Certain Stereoscopical Illusions Evoked by Prismatic and Cylindrical Spectacle-glasses. Trans. Am. Ophth. Soc., 449-456, 1889.

9. Bannon, Robert E.: Space Perception—Some Physiological and Psychological Aspects. Am. J. Optom. & Arch. Am. Acad. Optom., 29 (10), 499-511, (October), 1952.

10. Ames, A., Jr., and Kenneth N. Ogle: The Horopter and Corresponding Retinal Points. Annals Disting'd Serv. Found. Optom. (1), 35-45, 1932.

11. Ames, A., Jr.: Aniseikonia—A Factor in the Functioning of Vision. Am. J. Ophth., 18 (11): 1014-1020 (November), 1935.

12. Ames, A., Jr.: Binocular Vision as Affected by Relations between Uniocular Stimulus-Patterns in Commonplace Environments. Am. J. Psych., 59: 333-358, (July), 1946.

13. Ames, A., Jr.: The Space Eikonometer Test for Aniseikonia. Am. J. Ophth., 28 (3): 246-262 (March), 1945.

14. Ogle, K. N.: Association Between Aniseikonia and Anomalous Binocular Space Perception. Arch. Ophth., (30), 54-64, (July), 1943.

15. Ogle, K. N.: Theory of the Space Eikonometer. J. O. S. A., (36), 29-32, (January), 1946.

Ogle, K. N.: Researches in Binocular Vision. W. B. Saunders Co., Phila., 1950.

16. Ogle, K. N. and L. F. Madigan: Astigmatism at Oblique Axes and Binocular Stereoscopic Spatial Localization. Arch. Ophth., 33 (2): 116-127, (February), 1945

Burian, H. M. and K. N. Ogle: Aniseikonia and Spatial Orientation. Am. J. Ophth., 28 (7): 735-743, (July), 1945.

Ogle, K. N. and V. J. Ellerbrock: Stereoscopic Sensitivity in the Space Eikonometer. Arch. Ophth., 34 (4): 303-310 (October), 1945.

Ogle, K. N. and Ellerbrock, V. J.: Cyclofusional Movements. Arch. Ophth., (36), 700-735, (December), 1946.

Ogle, K. N. and W. Triller: Aniseikonia for Distant and Near Vision. Am. J. Ophth., (12), 1719-1724, (December), 1949.

17. Burian, H. M.: Influence of Prolonged Wearing of Meridional Size Lenses on Spatial Localization. Arch. Ophth., (30), 645-666, (November), 1943.

Miles, P. W.: A Comparison of Aniseikonic Test Instruments and Prolonged Induction of Artificial Aniseikonia. Am. J. Ophth., (31), 687-696, (June), 1948.

A CASE REPORT OF CONGENITAL IDIOPATHIC NYSTAGMUS*

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Nystagmus in any of its various forms has elicited a fair portion of comment in the leading ophthalmological texts and has been discussed adequately in most eye pathology courses in optometry colleges within recent years. However, reference to the anomaly in practice is scant and often incomplete. This paper presents one case history observed by the author in his practice with comments appropriate to the discussion.

On August 17, 1952, Mr. B. W. presented himself for examination with the comment that several eye practitioners were consulted within the past 10 years. In every instance a pair of lenses were prescribed but never has the patient experienced complete comfort and satisfaction. At the present the subject is a freshman in college, serving on the football varsity. High school grades and achievement were average but the patient has felt he has worked under a visual disadvantage and this handicap is now detrimental for further studying.

Only peculiar history datum was fainting spells around the age of five, but which disappeared a short time later. There is no history of strabismus, headaches or other major symptoms. Present glasses, obtained less than 30 days prior to the consultation with the author, proved to be unsuitable at all distances and at all times. The patient could not elaborate upon the difficulty other than stating "they just don't feel right." The subject has been wearing lenses as far back as grammar school, which helped somewhat. Frequency of change of prescription is about every 18 months.

Preliminary investigation shows a constant nystagmus during the history taking. Patient was asked whether or not he was aware of this and what subjective feeling did it arouse. The subject was aware of "something" but there was no motion observed in the field. This anomaly was bilateral, pendulary, and horizontal.

Comprehensive examination of the visual apparatus showed acuity below average corrected and uncorrected. Right eye was 20/39 at distance without correction and 20/33 with old correction; at near without correction 20/60 and with correction 20/40. The left eye was 20/90

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at distance without correction and 20/90 with old correction: at near without correction 20/60 and with correction 20/40. The prior examiner informed the patient the glasses were primarily for near work. This was inconsistent advice since the acuity at distance was equal with and without the correction, moderate plus: with the right eye the acuity increased with this "near correction."

External examination showed clear and healthy lids, cornea, aqueous, vitreous and iris. The fundus likewise bilaterally showed no signs of pathology or of physiological anomaly. The disc, vessels and nerve were all normal. The constant nystagmus made ophthalmoscopic inspection difficult but not impossible. There was no history of any pathology around the eyes or in the eyes. Pupil reflexes were normal, direct and consensual. Versions, parallax, and confrontation were excellent. Triangulation test repeatedly showed a maximum of 6 inches with a pen light and 7 inches with a pencil. It is expected the break point will be closer to the glabella with repeated trials.

Phoria at near and at distance without correction, with old correction and with subjective was 6 esophoria at near and 9 esophoria at distance. This was confirmed on three separate occasions. The rigidity of the phoria, even with application of plus and minus spheres, indicates that the phoria is structural rather than functional. Esophoria generally may be associated with toxemia but pertinent questioning of the patient failed to disclose any possible avenue of such toxemia. He is in exceptionaly fine health, both mentally and physically.

Subjective findings on two separate occasions were identical and showed in the right eye, +1.25 +0.75 x 85, and in the left eye, +1.75 cylinder x 105. Acuity with such a finding showed the right eye to be 20/33 at distance and 20/20 at near and intermediate with the left eye 20/50 at distance and 20/25 at near and intermediate. This subjective finding was substantially different from the five pairs of lenses the patient brought into the office and which were prescribed at different times during the past decade. No prescription showed prism of any kind and only one showed any cylinder correction. Conventional prism rules negatively indicated a possible base-in prism for utilization. However, placing 1 diopter prism, uniocularly and binocularly, in the four cardinal directions before the patient indicated a definite preference for base-in prism. This resulted in slight increase in acuity and fair improvement in comfort. The subjective finding of ½ base-in prism O.U. was prescribed with oral instructions to the patient that a lens change or changes may be necessary for final solution. Progress reports after 10, 20, and 30 days shows the patient is extremely comfortable.

acuity is nearly 20/20 at all distances O.U. and he is completely satisfied.

Until now, the case proved to routine in most instances, but the constant nystagmus presented subjective feelings of unrest, particularly after intense use of the eyes during studying.

Nystagmus may be considered to be an ocular posture disturbance characterized by rhythmic oscillations of the eyes. One major type of nystagmus, which this particular case occupies, is that of pendular variety. This type is smooth, equal speed in both directions, and equal amplitude in both directions. There are several possible planes through which nystagmus may operate: in this case it was confined to the horizontal plane. Further elaboration of nystagmus type and classification showed this patient to have a *fine* amplitude, which is one less than 5 degrees in excursions. Frequency of oscillations may be accurately determined on a nystagmograph, but estimation by the practitioner is sufficient for clinic purposes. Mr. B. W. has a frequency estimated to be around 150 oscillations per minute: this may be considered to be *medium*.

There are several excellent classifications of nystagmus, but for simplicity without sacrificing accuracy, it may be appropriately said that symptomatology of nystagmus varies widely depending upon whether or not the anomaly is congenital (or acquired very early in infancy) or whether or not it is acquired later in life. In congenital nystagmus it is found that the symptoms are not gross, objects do *not* seem to move, and central vision is poor.

Central nystagmus and vestibular nystagmus are characterized by the jerky type: pendular type observed in this case is rare in central and vestibular types. These types also lead to observable fluctuations only when the eyes are deviated from the primary position. This patient showed nystagmus evident in all directions of gaze.

In congenital idiopathic nystagmus the movements may be large and coarse, or fine: it is nearly always affecting both eyes: and in all cases it is horizontal in direction. The cause is obscure. In most cases it bears no relation to trauma incident to birth. It has been shown to be inherited in some cases, being transmitted as a dominant or sex-linked recessive characteristic. Most of the time, however, there is no history of inheritance. Quite frequently, astigmatic and hypermetropic errors of refraction are commonly found by the practitioner with individuals that are diagnosed as congenital idiopathic nystagmus.

Congenital nystagmus does not show head nodding but does often show wry positions of the head. Mr. B. W. did not nod frequently as we find in spasmus nutans, but he did hold head at a somewhat

peculiar angle, especially when requested to read. The two major points in diagnosing this type of nystagmus are, one: there is never evidence of disease or defect detectable, and two: there is an irremediable defect of acuity. This second point has been stated to be the *cause* of the nystagmus. Pigmentary failure, partial color blindness, optic atrophy are defects found in a minor group under congenital idiopathic nystagmus: this group is referred to by Duke-Elder as a recessive sex-linked type, male-limited and gynephoric. The patient referred to in this report was not abnormal in any way whatsoever in color vision, did not manifest pigmentary deficiency and did not show the characteristics of optic atrophy. The possibility exists the patient may fall into one of two remaining groups, classified by Duke-Elder. One is an ambi-sexual irregularly dominant form and the other is a simple recessive form: the second group is considered rare. Under such circumstances, the probability is that the patient may be liable under the ambi-sexual dominant form. There is no positive assurance as to exact classification.

The movements of the eyes become less marked in later years, and may in rare instances, cease entirely. However, congenital idiopathic nystagmus must be considered a permanent and untreatable anomaly by present knowledge. It is present soon after birth and persists throughout life. Because of the minute fluctuations and lack of gross symptoms in many cases, the parents are not aware of the problem until a comprehensive examination is undertaken. As in this case, the only procedure to follow is to give the patient the best possible prescription, if needed, and pertinent information on the anomaly.

REFERENCES

[1]Adler, F.: Gifford's Textbook of Ophthalmology; W. B. Saunders Co., Philadelphia, 1948.
[2]Blumenthal, I.: Headache: Diagnosis and Treatment: American Journal of Optometry, Vol. 27, No. 12.
[3]Cogan, D.: Neurology of the Ocular Muscles; C. C. Thomas Co., Springfield, Ill., 1948.
[4]Friedenberg, H.: A Case Report of Intracranial Tumor with Visual Complications and Comments on this Condition; American Journal of Optometry, Vol. 28, No. 9.
[5]Duke-Elder, W. S.: Text-Book of Ophthalmology—Vol. IV; C. V. Mosby Co., St. Louis, Mo., 1949.
[6]Kestenbaum, A.: Clinical Methods of Neuro-Ophthalmological Examination; Grune & Stratton, New York, 1947.
[7]Perera, C. A.: May's Manual of the Disease of the Eye; Williams & Wilkins Co., Baltimore, 1949.
[8]Sorsby, A.: Modern Trends in Ophthalmology—Vol. II; J. B. Hoeber, New York and London (Harper Bros.), 1947.
[9]Spurling, R. G.: Practical Neurological Diagnosis; C. C. Thomas Co., Springfield, Ill., 1950.
[10]Tassman, I. S.: The Eye Manifestations of Internal Diseases; C. V. Mosby Co., St. Louis, Mo., 1946.

CONTRIBUTION TO THE THEORY OF THE VERTEX REFRACTIONOMETER*

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The type of instrument known as Vertex Refractionometer or Vertometer was designed to afford rapid and accurate means of measuring the back vertex power of spectacle lenses. In this paper it will be shown how its use may be extended to measure the effective power of spectacle lenses and their magnification effects.

OPTICS OF THE VERTEX REFRACTIONOMETER

The instrument[1] consists essentially of two optical systems, K_1 and K_2 (Figure 1). When it is in its zero position an object placed

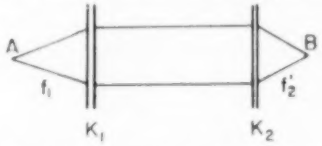

Fig. 1. Diagram of the Optical System of the Vertex Refractionometer in its Zero Adjustment.

at A, the first focus of the system K_1, is imaged in B, the second focus of system K_2. This image is viewed by the observer through an eyepiece. Let f_1 be the first principal point focal length of K_1 and f_2' the second principal point focal length of K_2. The magnification M_0 of the image in B of the object at A is given by

$$M_0 = f_2'/f_1 \qquad (1).$$

If a lens K is placed with its back vertex at C, the posterior focal point of K_1, the object will now have to be moved to D in order that a clear image be formed in B (Figure 2). Let AD be x and let the back

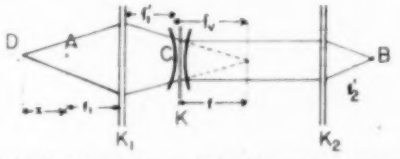

Fig. 2. Diagram of the Optical System of the Vertex Refractionometer with a Lens K in the Usual Position.

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vertex focal length of the spectacle lens be fv. The following relation holds:

$$fv = f_1'^2/x \qquad (2).$$

This may be re-written

$$Fv = a\,x \qquad (2a),$$

where a is a constant depending on the instrument. This equation shows the linear relationship between Fv, the back vertex power of the spectacle lens under measurement, and x, the distance through which the object has been moved. This is the conventional method of using the instrument.

MEASUREMENT OF THE EFFECTIVE POWER OF A SPECTACLE LENS WITH THE VERTEX REFRACTIONOMETER

Suppose that the same lens is now placed with its back vertex in G, the distance CG being denoted by k (Figure 3). In order that a

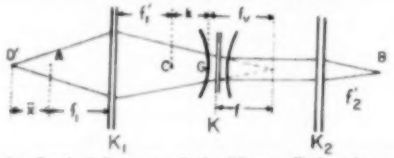

Fig. 3. Diagram of the Optical System of the Vertex Refractionometer with a Lens K placed with its Back Vertex in G, a Distance k from the Usual Position.

clear image of the object again be formed in B, it is necessary to move it to D', where $AD' = \bar{x}$. The following relationship now holds

$$fv + k = f_1'^2/\bar{x} \qquad (3)$$

or

$$1/(fv + k) = a\,\bar{x} \qquad (3a),$$

showing again a linear relationship between the effective power of the lens, $1/(fv + k)$, and the distance $\bar{x}$ through which the object has been moved. Equation (3a) has the same constant a as equation (2a) and this means that the same scale is applicable in both cases.

The practical application of equation (3a) is the following. Suppose a patient's refraction was determined at a distance $h + k$ in front of the cornea, the correction having a back vertex power $\bar{F}v$. We require the power Fv which would equally correct the patient's eye when placed at the distance h in front of his cornea. From equations (2a) and (3a) it follows that we merely have to place the correction $\bar{F}v$ at a distance k from the usual position of the lens in the vertometer and read

the required effective power Fv on the indicator in the usual manner. Due attention must be given to the sign of k.

MEASUREMENT OF THE MAGNIFICATION PROPERTIES OF SPECTACLE LENSES WITH THE VERTEX REFRACTIONOMETER

The magnification M of the image formed in B by the combined effects of systems K_1, K and K_2 (Figure 2) may be considered[2] as the product of M_1, the magnification contributed by system K_1, and M_2, the magnification contributed by systems K and K_2 acting together in the same way as K_1 and K_2 in the original zero adjustment of the instrument (Figure 1).

M_1 is given by

$$M_1 = f_1/x = fv/f_1' \qquad (4)$$

and M_2 is given by

$$M_2 = f_2'/f \qquad (5)$$

where f and fv are the principal point and back vertex focal lengths, respectively, of the lens K under measurement.

Combining equations (4) and (5) and using (1) we obtain

$$M = M_1 \cdot M_2 = M_0\ fv/f$$

or

$$Fv/F = M_0/M \qquad (6).$$

This equation relates F, the principal point power of the lens K, to Fv, its back vertex power, M, the magnification of the object in the vertometer when the lens K is in position, and M_0, the magnification with the instrument in the zero adjustment and without the lens K.

A direct application of this method is in the measurement of the magnification or "size" effect of a spectacle lens. The magnification[3] m of a spectacle lens of back vertex power Fv and principal point or equivalent power F over that of a thin, flat trial lens of equal back vertex power and equally positioned in front of the eye for an object at infinity is equal to the ratio Fv/F. Substituting in (6) we obtain

$$m = M_0/M \qquad (7),$$

relating m, the magnification of the spectacle lens, to the ratio M_0/M, a quantity which may be obtained from the vertometer by direct measurement if a suitable scale is placed in B, the reticle plane of the eyepiece.

It is, however, not necessary to restrict oneself to the case in which the trial and final corrections are placed in identical positions relative to the eye. If two corrections equally form an image of an object at infinity in the far point plane of the eye, their relative magnifications will be equal to the ratio of their principal point focal lengths. Equation (7) thus remains valid even when the eye-lens separation has been changed.

The aim in the correction of aniseikonia is to effect such a change in the principal point focal length of the correction as is necessary to change the size of the image in the far point plane of the eye, the image, however, always remaining in this plane. This may be achieved by changing the thickness and base curve of the lens and also its position in front of the eye. When the changes are merely in the thickness and base curve of the lens, it suffices to specify an invariant back vertex power. When, in addition, changes are made in the eye-lens separation, effective power calculations become necessary.

In all these cases, however, a determination that the final correction does, in fact, achieve its aim can be made by the method just described. Assume that a thin flat trial correction with a certain added magnification was found to correct the patient's ametropia and aniseikonia when placed at a given distance in front of his cornea. The final correction, incorporating such changes in thickness, base curve and eye-lens separation as are necessary to secure the magnification effects, may be checked by placing it in the vertometer in the same position relative to the usual position of a lens under measurement as the completed lens is placed relative to the trial lens. Measuring the power in the usual way provides a check whether the correction actually forms an image in the far point of the eye (see equations (3) and (3a) and the relevant discussion). Measuring the ratio M_0/M, i.e., the change in magnification of the target in the vertometer, we obtain the magnification of the finished correction relative to that of the original trial correction and this affords a check whether the required magnification has, in fact, been achieved.

The magnification of a telescopic system will also be given by the ratio M_0/M. Moreover, when the system is afocal its exact position within the instrument is immaterial. A vertometer thus enables the magnification of telescopic spectacles to be measured and this can be done with a reasonable degree of accuracy on the ordinary instrument without any special attachments.

For the measurement of usual iseikonic effects the ratio M_0/M will have to be determined with some precision. If the size of the image in B is of the order of 10 mm. a micrometer eyepiece capable of measuring to .01 mm. would give an accuracy of about 1/10 per cent.

It will be noticed that the ratio M_0/M will give percentage magnification on a non-linear scale. This may be overcome by reversing the usual positions of the object and the eyepiece reticle resulting in a direct reading of the magnification on a linear scale.

The method can also be utilized to measure the principal point

power of an optical system and this is the way in which Godfrey[2] applies it.

It ought to be pointed out in conclusion that the formulae and effects described in this paper are derived from and hence remain valid only within the limitations of the usual Gaussian laws of image formation.

SUMMARY

(1) An extension of the usual mode of operation of the vertex refractionometer is described, showing that the effective power of a lens may be measured by placing it in the instrument at a distance from its usual position which is equal to the difference in the eye-lens separations of the trial and final corrections.

(2) A method is described enabling the direct determination of the magnification effects of spectacle lenses. It involves the measurement of the change in magnification of the target in a vertex refractionometer.

REFERENCES

[1]Emsley, H. H. and Swaine, W. "Ophthalmic Lenses," Hatton Press, London, 5th Ed., 1946, p. 183.
[2]Godfrey, G. H., Austral. J. Appl. Sc., 1950, 1, 147.
[3]Westheimer, G., Austral. J. Optom., 1949, 32, 115.

ACADEMY COMMITTEE APPOINTMENTS FOR 1953

Dr. Meredith W. Morgan, Jr., president, announces the following committee appointments for 1953:

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INTERPRETATION OF REFRACTIVE DATA

In a recent paper dealing with the interpretation of refractive data Michaels[1] finds the profession split into several segments. He mentions two of these groups by name. First, those practitioners who follow the Optometric Extension Program and next the unorganized group of optometrists who utilize what he calls the "graphical approach." He finds the thinking of these two groups at considerable variance and sees trouble ahead. Michaels finds the current friction unnecessary, and feels it retards the science and regrets that the friction exists.

[1]David D. Michaels. For Greater Unity in Optometric Analysis. The Optical Journal and Review of Optometry. Vol. XC., No. 2, pp. 36-42. 1953.

At this point in his paper Michaels fails to mention the much larger, though less vocal group of optometrists who follow neither viewpoint, but who seem to rely for their final diagnosis upon the more conservative teachings of the past. These are teachings which incidentally still serve as a basis for our refractive techniques, not only in this country, but the world over.

In his paper, Michaels mentions some of the drawbacks of each system of analysis and points out certain of the problems and shortcomings in these programs. For instance, one of his minor comments deals with the numerical sequence of optometric tests recommended by the O.E.P. Here the author finds there is a tendency on the part of some to think only in terms of numbers. These men seem to forget that these same number-names represent tests of specific physiologic functions. This is not the fault of the program as the number-names were substituted for the names of tests only for brevity. Writers and speakers for the O.E.P. may easily rectify this problem.

Michaels fails to add, however, that where this numerical terminology is used exclusively, that the uninitiated (and there are a great number of these who do not know what the number-names stand for) are unable to understand the speaker or the author and as a consequence, papers written in which number-names are used are for limited consumption only. Scientific publications in optometry with large subscription lists must therefore require their authors to use each proper test name for each test mentioned in their original papers so that all readers may understand just what is meant as the theme of the paper develops.

Michaels also mentions the objections raised by some to the O.E.P. table of average expected clinical findings and the O.E.P. proposal to compare case refractive findings to this table in a somewhat rigid manner. He finds in the graphical approach the possibilities for somewhat the same criticism and cries aloud that the abundance of new coined terms, such as "learned visual projections," "visual field restructuring," and similar phrases are confusing and not conducive to clear thinking or analysis. Furthermore, as Eugene Freeman has pointed out, it is a violation of the rules of scientific method to attempt to replace a well established term that clearly designates a familiar concept by a new and unfamiliar term.

The author somewhat evades the whole controversial issue of the etiology of ametropia. He does, however, point out that it is somewhat illogical for some to blame myopia on environment when we have little or nothing to base this on but conjecture. This subject is timely and important. The research work now being done by Monroe J. Hirsch

at the Los Angeles College of Optometry is the sort of thing which may in time remove the present day questions and give the profession some real facts upon which to base our procedures.

Michaels then gets around to some of the theories on perceptual psychology which have been introduced into this whole discussion, particularly those presented during the past six or seven years relating to the Gestalt methodology. Michaels finds that in general optometrists are poorly trained for understanding this material. They lack the psychological background to absorb it properly and usually are confused because of it. For example—Gestaltists believe primarily in the innateness of functions. Yet optometrists who have adopted this branch of psychology assume that all functions are learned.

As an educator Michaels finds that in general students in our colleges are unhappy with this state of affairs as it tends to undermine their confidence in the material which has been given to them in their undergraduate courses. Many optometrists, too, he finds, share this same feeling. As an educator he expects differences of opinion. He does not however relish the intolerance and dogmatism he finds in these discussions.

Michaels suggests that more research programs similar to those carried out at the Schools of Optometry at The Ohio State University and the University of California be developed. These programs should work in the field of experimental analysis and will in time solve these and other problems. He points out that the schools and colleges in optometry have the laboratory facilities and the trained personnel to do the job. He calls for optometric leadership of high order to bring the factions together and to develop research programs which over the years will bring out the facts in the best interest of the profession as a whole. He believes this can readily be done and that all groups will benefit.

His suggestions are, for the most part, sound. Michaels will receive much criticism from the extremists who can only see good in their particular beliefs of the moment. But he must be encouraged in his forthright stand in calling for cooperation and order in this vital field of science. His plea for tolerance and understanding is timely and the need for it is real. We hope the profession gives his ideas the support they properly deserve.

CAREL C. KOCH

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

NATIONAL BOARD TO GIVE SECOND ANNUAL EXAMINATION

The National Board of Examiners in Optometry decided at a meeting in Chicago in December, to give its second annual examination June 29 and 30, and July 1, 1953. This year, both Part I and Part II will be given to applicants; last year only Part I was given. The examinations will be given at convenient testing centers throughout the United States.

Applications to take the examination must be submitted to the board before May 1, 1953. National Board officers for 1953 are Dr. Rudolph H. Ehrenberg, Granite Falls, Minnesota, president; Dr. John R. Uglum, Mitchell, South Dakota, secretary-treasurer, and Dr. William J. Goyer, Hattiesburg, Mississippi, vice president.

Senior students in our colleges and schools should secure additional information regarding these examinations from their school Registrar or Dean of Student Affairs.

MEETINGS: PAST, PRESENT, AND FUTURE

CALIFORNIA: The 48th Annual Convention of the California Optometric Association will be held in Santa Barbara February 20-23, with convention headquarters at the Mar Monte Hotel. Theme of the meeting will be "Fine Education, Fellowship, and Fun." At the four educational sessions, guest speakers will be Dr. Carel C. Koch, Editor, American Journal of Optometry, and Secretary, American Academy of Optometry, Minneapolis, Minnesota; Dr. Marvin Flom and Dr. Henry Knoll, Los Angeles College of Optometry. At special department and committee panel meetings the subjects of ethics, public relations, legislative, and occupational vision problems will be discussed.

WINNIPEG CANADA: Canadian optometrists will hear Dr. Henry W. Hofstetter, director, Indiana University Division of Optometry, at their annual Manitoba Optometric Society convention, February 23-24 at the Fort Garry Hotel in Winnipeg.

NEW YORK: "Better Sight for Tomorrow" will be the theme of the 1953 national prevention of blindness conference, to be held March 18-20, at the Hotel Statler, New York City. Subjects for dis-

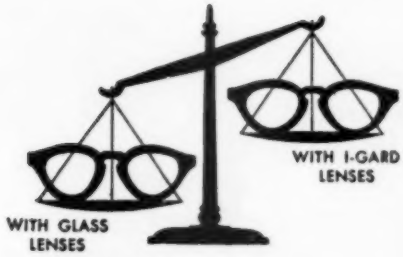
cussion at the conference include sight restoration programs for children and adults; current scientific methods of handling various eye defects and diseases; eye safety programs through industry; how blindness can be prevented through community wide programs. In announcing the 1953 conference, Dr. Franklin M. Foote, Executive Director of the National Society for the Prevention of Blindness, reported that blindness in this country is increasing at the rate of 4,800 persons every year, and said. "During 1953 we must intensify this continuing battle against needless blindness."

In New York also, will be the Eastern States Optometric Congress meeting at the Hotel Statler April 19, 20 and 21. Speakers will be Dr. John Paul Nafe, professor of psychology, Washington University; Dr. Leo Manas, Northern Illinois College of Optometry; Dr. Thaddeus Murroughs, Chicago, Illinois, and Dr. A. M. Skeffington. There will also be a visual training workshop under the direction of Dr. Walter J. Wittman. Optometrists in charge of the Eastern Congress are Dr. Henry Quick, Oswego, New York, and Dr. Nathan A. Robbins, Buffalo, New York.

MINNESOTA: Tips on figuring income tax were part of the program of the Minneapolis District Optometric Society at a recent meeting. Advice on optometric economics and tax accounting was given by Leo Stein, guest lecturer from Chicago College of Optometry. The meeting was part of the Society's five series educational program of "bringing the college to the practicing optometrist."

The Minnesota Optometric Association 1953 State convention will be held April 12-14 at the St. Paul Hotel, St. Paul, Minnesota, with Sylvester Guth, General Electric Lighting Engineer, a guest speaker. Motorists' vision will also be discussed by special speakers.

ILLINOIS: A three-day meeting of members of the Illinois Optometric Association was held at the Sheraton Hotel in Chicago in February. Speakers at the educational sessions were Dr. Chauncey Maher, Sr., M.D., associate professor of medicine, Northwestern University Medical School, Dr. Carl Shepard, Chicago; Dr. Henry W. Hofstetter, director, division of optometry, Indiana University. All phases of optometric practice were discussed at panel meetings.



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Translated from the original German by

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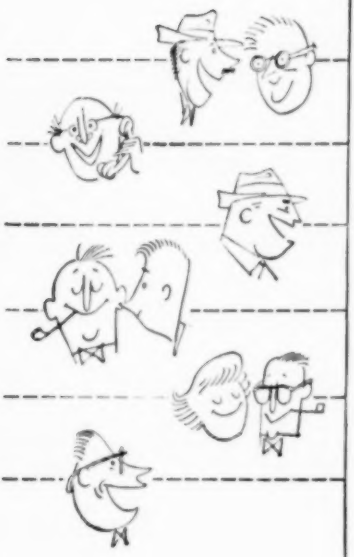

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